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POUR L'EXPLORATION DE LA MER

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E. S. RUSSELL

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MARS 1931

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IMPRIMERIE BIANCO LUNO A/S

Some theoretical Considerations on the "Overfishing" Problem.

By

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I. Elementary Formulation of the Problem.

1. To decide in any given instance whether fishing operations are or are not being carried out in a manner ultimately wasteful to the stock is admittedly a difficult task, for the conditions to be taken into account are extremely complex and extremely variable, and the data available are as a rule incomplete and not always easy to interpret in an unequivocal way. Yet notwithstanding this difficulty of application to the concrete case there are certain general principles about which there can be no reasonable doubt and about which everyone should be agreed. It is my aim here to formulate in a simplified and general way, and without mathematical treatment, the broad facts of the case, to state in simple language those elementary principles that are at the back of everyone's mind who deals with the problem of the rational exploitation of the fisheries. Most of the truths to emerge will appear as obvious truisms, but there is, one feels, a distinct advantage to be gained by formulating in a simple way the essential conditions of the problem, as a help towards its more detailed study.

2. Let us simplify the problem down to its bare essentials by considering a completely self-contained stock of fish of one particular kind living in a large area which is systematically fished. Let us further assume that the fishing gear used is standardised and is such that all the fish reaching a length l are liable to capture and that none of length less than l are caught. The total stock in the area may then be divided into those of l and upwards in length and those less than l, and we shall call these respectively the catchable stock and the non-catchable stock.

Let us consider what will happen to a given catchable stock of initial total weight S_1 over a period of time which we may take for convenience as one year. We will assume that the individuals comprising the total stock grow, i. e. increase in weight, during the period, and that the total stock is recruited in the normal way by annual broods.

Considering first the catchable stock with which we start (S_1), we may say that each individual either survives to the end of the year, having grown in the interval, or is caught, with a growth-increment depending on the length of time it has survived, or is otherwise eliminated after a varying period, also with the equivalent growth-increment. The catchable stock will, however, during the year receive additions due to the non-catchable stock growing up to the limit l. The individuals comprising this added stock will, as soon as they enter the catchable stock be subject to the same chances as those making up S_1, i. e. will either survive to the end of the year, or be caught, or die from other causes before the end of the year, in each case with the appropriate growth-increment. We can accordingly deduce the weight of the catchable stock at the end of the year (S_2) from the weight at the beginning of the year (S_1) as follows.

On the credit side we must start with S_1, and to this add the sum of the initial weights of all individuals (new stock) transferring from the non-catchable to the catchable category, as they reach the length l. Let us call this sum Σa; to this we must add the sum of the growth-increments of all individuals surviving at the end of the year (Σg) whether belonging to S_1 or to the new stock; from this total we must subtract the sum of the weights of all fish caught during the year (Σc) and the sum of the weights of all fish which have died from natural causes during the year (Σm). Σc and Σm of course include the growth-increments of the fish which have been caught or have died.

We get then $S_2 = S_1 + \Sigma a + \Sigma g - (\Sigma c + \Sigma m)$ or, using capital letters for the sums,

$$S_2 = S_1 + (A + G) - (C + M).$$

S_2 will therefore be $> =$ or $< S_1$ according as $(A + G)$ is $> =$ or $< (C + M)$. In other words, if more is taken out of the catchable stock in a year $(C + M)$ than is replaced by natural processes $(A + G)$ the total weight of the available or catchable stock will diminish; if the loss balances the gain the available stock will be the same at the end of the year; if the natural replenishment is greater than the loss due to fishing and other mortality the available or catchable stock at the end of the year will have increased. This is self-evident, and the sole value of the

exact formulation given above is that it distinguishes the separate factors making up gain and loss respectively, and is therefore an aid to clear thinking.

(A) conveniently represents in terms of weight the influx of smaller individuals (belonging for the most part to younger year-groups) which have just reached catchable size. (A) accordingly separates out mainly the effect of "fluctuations", due to good or bad brood-years, upon the catchable stock. (G) represents the total growth-increment of the surviving individuals — of the remnant of S_1 and A. It will presumably vary according to the conditions in the area as regards e. g. food and temperature. (C) is a datum to which an approximately accurate numerical value can in certain cases be assigned. It does not necessarily coincide with the total landings from the area, for to the landings must be added the weight of all individuals caught but discarded.

3. In this formulation of the problem we have essentially to do with a number of processes, the rate of which may vary. This applies to all those factors which were treated above as summations, namely A, G, C and M. The value of A depends upon the rate of introduction of new individuals to the catchable stock, which is in turn dependent (1) on the number growing up, and (2) on their rate of growth, while belonging to the non-catchable stock; G clearly varies according to the rate of growth; C varies according to the rate of catching, M according to the rate of natural mortality. It is important then to consider what is the effect upon the stock of variation in the rate of these processes, having regard also to their necessary inter-connections.

Here it is important to make quite clear in which terms, whether of number or of weight, we state the rate of change of the processes whose summated values we have so far treated only in terms of weight. It is clear that rate of growth should by definition be stated in terms of increment of weight. Rate of capture, rate of natural mortality, and rate of introduction of new stock, might be stated in terms either of numbers or of weights, but there is an obvious advantage, for clarity of thought, if we state them in terms of numbers, for these rates will then be independent of variations in rate of growth. We shall accordingly in the following discussion use rate of capture, rate of natural mortality, and rate of introduction of new stock as referring to numbers.

4. We shall consider first the effect of variation in the rate of catching. This we define as the number caught per unit of time by the standard fishing gear. There seems no objection to defining the rate in terms of number and not of weight, because the chances of capture (above length l) are, so far as we know, independent of the size of the fish. We may con-

veniently start from the theoretical case where in a specified year $A + G$ just balances $C + M$: a condition of stabilisation, in which $S_2 = S_1$. The rate of catching (number) is such as to give the value C (weight). We may call this Case (1). Let us now assume that in Case (2), the rate of growth, the rate of natural mortality and the rate of introduction of new stock remain constant, but that the rate of catching is lower than in Case (1). It follows immediately that in Case (2) $C + M$ must be less than in Case (1), for total mortality is by hypothesis less. Similarly G will be increased in value, since the number of survivors is greater in Case (2) than in Case (1). The total weight and number of the stock will therefore be greater in Case (2) than in Case (1); the stock will therefore have increased, owing to the decreased rate of catching. In the above argument we deal with the individuals making up both S_1 and A. If we now assume that in Case (3) the rate of catching is increased we arrive by the same simple reasoning at the conclusion that the stock in this case will diminish in total weight and total number.

But it is important to note the assumptions on which these conclusions depend, namely the constancy of rate of growth, rate of natural mortality, and rate of introduction of new stock. Are these assumptions justifiable on biological and mathematical grounds? Have we the right to assume that the rate of capture may vary independently of each and all of the other factors? Taking A first of all, it is difficult to see how variations in the intensity of fishing could in the course of a year have any direct effect upon the numbers of the new stock growing up i. e. upon the numbers of the non-catchable stock — unless of course the species were cannibalistic. Even if fishing were so intensive as to wipe out all potential spawners, the direct effect of this would under present conditions of fishing not be seen till at the earliest 18 months after the spawning season (taking the case of the haddock as a typically fast growing fish). An indirect effect through the rate of growth of the non-catchable stock is, however, conceivable, for a vast clearing out of catchable stock might leave more food available for the non-catchable stock and increase their growth-rate so that they reached size l more rapidly. Λ in such a case might be increased, if more survived to length l owing to their passing through the vicissitudes of early life more rapidly.

This brings us to a consideration of the possible effect of variations in the rate of capture upon the growth-rate of survivors. It is quite conceivable that increase in capture-rate should result in increase of growth-rate of survivors, since the amount of food made available would, *ceteris paribus*, increase. One condition must, however, be fulfilled before this conclusion follows — the supply of food must not be in excess

of requirements. If the food supply were superabundant, the growth-rate in all three cases considered would be at the maximum possible under the other conditions prevailing; variation in rate of capture would then be of no effect on rate of growth. If, however, — and this seems the more likely case — the food supply is relatively limited and there is consequent competition for it by many species, it seems reasonable to suppose that increase in rate of capture might result in increase of growth-rate, both of catchable and of non-catchable stock. Whether it is possible in such circumstances for the increase in G, due to increased growth-rate to equal or exceed the decrease in G due to increased capture-rate is a complicated problem which cannot be considered here. It may, however, be remarked in passing that any food "released" by increase of capture-rate would be eaten by other species besides the one considered.

As to the effect of variations in capture-rate upon the rate of natural mortality it is impossible to say much from the biological point of view. If any part of the natural mortality were due to starvation, or to cannibalism, then increase in capture-rate would tend to lower natural death-rate. There is of course on purely arithmetical grounds a certain inverse relation between C and M; $C + M$ represents total mortality (in terms of weight); if C increases it will diminish M, since some individuals will be caught which would otherwise have died a natural death; similarly if M is increased it must diminish C as some individuals will die which would otherwise have been caught.

5. We have established the fact that A, G, C and M are or may be inter-connected biologically. It is therefore a little dangerous to attempt to treat the variations in rate of each of these factors singly. We have attempted to do so with the rate of capture, but it is necessary to bear in mind the qualifications and corrections to be applied. We may now consider the broad effects of variation in the other rates, namely rate of introduction of new stock (expressed in numbers), rate of growth (expressed in weight) and rate of natural mortality (expressed in numbers). It is clear first of all that A is a highly important source of variation. We know that in practice the numbers of the on-coming new brood may vary enormously from one year to another. Starting out from our standard Case (1) and assuming the other rates specified to be constant, a big increase or decrease of A would clearly make a considerable difference to resultant stock (S_2). In practice a big increase might depress rate of growth, but, leaving this out of consideration, it would certainly increase C, M and S_2, as compared with their values in Case (1).

An interesting result emerges if we assume that, for any reason

unconnected with variation in capture or mortality rate, the growth-rate is increased. As compared with our standard Case (1), C and M would be increased, and G also, and the increase in G would over-compensate the increase in C and M, so that S_2 would be greater than S_1, though there would be no increase in numbers. The truth of this conclusion is easily checked by considering that in both cases the number of survivors is the same, but their weight is greater in the second. So too the number caught and the number naturally eliminated are the same in the two cases, but in weight they are greater in the second case than in the standard case. Increase in growth-rate in such conditions means increase in weight of catch and at the same time increase in weight of surviving stock. The importance of high growth-rate in increasing the yield of a fishery is clearly brought out by these considerations.

The effect of variations in rate of natural mortality has already been dealt with in part in the preceding section, where it was shown that M would increase partly at the expense of C. The effect of a large increase in natural mortality rate in decreasing resultant stock is obvious and needs no detailed comment.

The main object of the above discussion has been to show that in considering changes in catchable stock from one year to another there are several other factors to consider besides variation in the rate of capture, and an attempt has been made to indicate the direction in which these other factors would work, whether as increasing or as decreasing the resultant stock.

6. From the theoretical point of view it is of interest to discuss the two extreme cases of variation in rate of capture — (1) where the rate is nil, and (2) where it increases to an indefinitely large degree. Let us take (1) in its most extreme form and let us consider the case of an area which has never been fished at all. Knowing that the total amount of available food cannot be unlimited, we can deduce that there is a maximum value for S which cannot be exceeded. Let us assume that on a virgin ground the stock tends to approximate to this maximum and that the amount of food remains constant from year to year. S will under these conditions remain stationary, and for any year we may write $S_2 = S_1$. It follows also that $A + G = M$. This means that the mortality rate and the rate of replenishment and growth of the catchable stock must vary together; if M is small the annual increase $(A + G)$ must likewise be small.

Let us see how this would work out in practice. Assuming the supply of food to be limited in relation to existent stock and the stock eating up the food as fast as it is produced, there must inevitably be competition

between the fish for the available food. There is a broad difference between the old fish and the young fish in respect of their utilisation of the food — the young fish put relatively more to growth and less to maintenance. If therefore on the whole the older fish win, the stock will gradually become composed of large old fish which utilise all the food for mere maintenance and do not grow, and M will consist mainly of small fish which have been starved out of existence. If on the contrary the younger fish manage to annex more than their share they will grow at the expense of the older fish, which will die of starvation; M will then consist mainly of the larger fish. Without some knowledge of the actual facts it is impossible to say what theoretical formulation comes nearest to the actual conditions found on a virgin ground.

Even the few theoretical conclusions arrived at above as to the state of things on a virgin ground, may not correspond accurately to what is actually found; in particular the assumption that a maximum is reached and steadily maintained may be a wrong one. This much is, however, certain, that there is a theoretical maximum to S and that mortality and replenishment must in some way balance one another — possibly in a cyclical manner.

Coming now to the second limiting case of variation in rate of capture, it is easy to see that an indefinite increase in the rate would lead to a virtual extermination of the stock, first by reducing to indefinitely low numbers the existent stock and, through destruction of the spawners, reducing A in course of time to nearly zero. This is of course a limiting case, never actually met with so far as fish are concerned, but it brings out the possible danger to stock through undue destruction of spawners brought about by very intensive fishing.

7. If now we consider the size-distribution of the catch, under different rates of capture and different rates of growth, certain obvious deductions can be drawn. Other factors being constant, an increase in rate of capture will mean a diminution in the average size of the catch, as compared with that in the standard case, since the individual fish will on the average be caught earlier, i. e. at a smaller size, than if fishing is less intensive. An increase in rate of growth will obviously act the other way — if capture-rate is constant, but rate of growth increases, the average size of those caught will be greater. Decrease in growth-rate will give the same kind of result as increase in capture-rate — a decrease in the average size of those caught.

8. Coming back now to our starting point, we may say that the formula stated in paragraph 2 above represents a balance-sheet. We start with a working capital S_1; to this is added in the course of a year

$(A + G)$, and from it is taken away $(C + M)$. At the end of the year our working capital is S_2, which will be greater than, equal to, or less than S_1, according as income $(A + G)$ has exceeded, equalled or fallen below expenditure $(C + M)$. S_2 is what is carried over as capital from one year to the next. It does not represent merely the difference between income and expenditure but that difference added to or subtracted from S_1. S is therefore a continuing value which alters according to the difference between income and expenditure.

It is clear that if expenditure is consistently higher than income, S will be a diminishing quantity, and that if the amount of fishing remains constant during this process C must also fall. The practical problem then appears to be to keep S at such a level, or to bring S to such a level, that the maximum value of commercially utilisable fish can be drawn from it annually without causing a progressive diminution of S. If the annual increment represented by A were fairly constant from year to year, the problem would be one of obtaining a constant maximum yield. It might be theoretically possible to evaluate this optimum yield and to estimate the amount of fishing required to obtain it. A stabilised fishery would be the result. It is, however, common knowledge that A is a fluctuating quantity and that in certain important fish, e. g., haddock, the fluctuations are very great.

It appears therefore that the ideal of a stabilised fishery yielding a constant maximum value is impracticable. It might, however, be practical politics to attempt to adjust the amount of fishing each year to the variations in the stocks of particular fish in particular regions, as even now fishing does shift to some extent according to the abundance or scarcity of fish in particular regions. If such variations in abundance could be foretold a year or so in advance this adjustment could be made more rapidly and with more certainty of success.

9. The problem of rational exploitation is, however, an exceedingly complicated one. Let us arbitrarily simplify it by assuming that A is constant from year to year, i. e. that fluctuations do not exist. (Probably if we take a sufficiently long series of years fluctuations do average out). It is clear that a condition of stabilisation exists when $C + M = A + G$; S_2 in this case equals S_1, and the stock remains constant from year to year. But it is also clear that this stabilisation may take place at various levels, depending on the magnitude of C. If $C + M$ is small, $A + G$ will also be small, and the annual product of the fishery will be well below the maximum possible. But the aim of rational exploitation is to get the maximum yield annually, compatible with maintaining stocks at a steady level.

Regarding M as a constant factor, and in any case as outside control, our problem is to increase C as much as possible while keeping S constant from one year to another.

An increase on the credit side ($A + G$) would be achieved if it were possible to increase the rate of growth (as can be done for example to a limited extent by transplantation in the case of plaice). This would result, if other conditions were constant, in an increase in C, as was shown in paragraph 5 above.

With regard to the debt side ($C + M$), clearly much depends upon l, the theoretical limit between catchable and non-catchable stock. Hitherto we have assigned no particular value to l, but in practice, as we all know, l tends to approximate to, but to be less than, the size at which the fish becomes of marketable value. In what follows we shall assume that the value of l corresponds roughly to something less than the commercial minimum.

It would seem that C might be increased by lowering l, but clearly this would be of no value commercially, and it would of course decrease A, and lead in the long run to a diminution of S. Let us consider what would be the effect of increasing l by a moderate amount, say the amount represented by one year's growth in length (n).

If the limit were increased to $l + n$, the catch would at first be less, but $A + G$ would increase. Now consider the state of affairs after one year, when the fish of length l had grown to $l + n$. If M were low there would not be many fewer fish of length $l + n$ at the beginning of the year than there were of length l a year before, and, since weight increases as the cube of length, their weight would be very much greater. The catchable stock at the beginning of the second year would be increased in weight, and C would therefore be greater during the second year. A and possibly G would also be increased. The net result should be that with equal intensity of fishing the yield would be greater. But the process of increasing l could not be carried very far without entailing drawbacks. There would be an increasing wastage from natural mortality among the non-catchable stock, and it is at least conceivable that rate of growth would be diminished; it is probable also that as heavier stocks of non-catchable fish were accumulated there would be less room and food for the incoming new brood, and renewal of stocks would be slowed down.

It is clear that this question of the best size at which to commence capture raises problems of great complexity which require a fullness of treatment which cannot be attempted here. In particular the effects,

both beneficial and harmful, of the "thinning" of the stock above and below the commercial minimum size demand most careful analysis.

11. We have attempted in the preceding paragraphs to give a simple and general formulation of the problem of "rational exploitation"; it is obvious, however, that an abstract formulation is of little value if it cannot be applied in practice. This raises at once the question, can we measure or estimate the changes in the stocks of fish? I propose to consider this question in the second part of this paper, leaving to a later occasion the concrete study of the "overfishing" problem in the light of the available statistical evidence.

II. Can we Measure Changes in the Stock?

The measure commonly adopted of the abundance of fish on a ground is the catch — more properly the landing — per day's absence from port. In Great Britain of recent years a more accurate measure, the landing per 100 hours' actual fishing, has been employed. The landings are of course given in terms of weight.

It is clear that these values do not give any definite indication of the absolute quantity of catchable fish on the grounds visited, and do not allow of any actual value being allotted to S. They represent the weight of commercially valuable fish taken over a certain period of time with certain fishing implements, but what proportion this weight bears to the total catchable stock (S) on the grounds fished remains unknown[1]).

They have, however, relative or comparative value. We may assume that a trawl of a certain spread, a certain height of head-line, a certain cod-end mesh, fished at a certain speed, takes on the average a constant proportion of the total number of fish of catchable size present at the time, whether the fish be numerous or scarce. If this fundamental assumption is sound, then the amount of the catch per unit of time is a valuable index of the total weight of catchable fish on the ground, and may be used for studying the variations of S in space and in time. Without information as to the size of the fish caught it cannot of course be used as an index of the number of fish of catchable size on the grounds.

As has already been indicated, we have to deal in the commercial statistics not with catches, but with landings. This makes our index less accurate, for a varying amount of fish is caught which is not brought to market, owing to its negligible commercial value. On occasions the weight of the discarded fish may amount to a considerable fraction of

[1]) Total catchable stock might be estimated in a rough way from the results of extensive and successful marking experiments.

the total catch, if fishing has taken place in areas where undersized fish abound. Nevertheless, with due precautions, the landings per unit of fishing time may be used for comparative purposes as roughly equivalent to the catches.

It will, however, be apparent that certain conditions must be fulfilled before the landing, or even the catch, per unit of fishing time, can be safely used as an index of the comparative abundance of the catchable stock.

The single haul, or group of hauls, on the same ground on the same day, gives an index of abundance which is valid only for that particular ground at that particular time. If we wish to have a reliable index of the abundance of the stock over a large area we must have numerous hauls well distributed over the whole extent of the area in question, especially if, as is almost invariably the case, the abundance of the fish varies with locality. Furthermore, since the stock (weight) of the fish in a given area is a varying quantity, constantly affected by migration into or out of the area, by the effect of fishing operations, by increase of weight due to growth, by the introduction of new stock, and by other causes, the value of the catch per unit of fishing time, deduced for the area as a whole, during a given short period of time, is valid only for that period.

It follows then that for the catch per unit of time to have general validity for any area the sampling must be adequately distributed over that area; even then, the values can be accurate only over limited stretches of time, since the stock is a changing one. The catch (or landing) per unit of fishing time should therefore, strictly speaking, be used as an index only over short periods of time, since the quantity of which it is an index is a constantly changing one. Practical considerations make it difficult, if one is dealing with large masses of data, to use a shorter period than a month, and our British fishery statistics are accordingly for the most part tabulated by months. In practice, however, it is found that the landing per unit of fishing time can be usefully employed even over such periods as a year, but of course only when very extensive and adequate data are available. Used over such long periods it gives an average index for the weight of catchable stock during the period and in the area considered, i. e. a value which is or may be accurate only for a short time during the period. Nevertheless this average index has a perfectly definite meaning mathematically. Its meaning may also be expressed in practical terms as follows — it gives the relation between yield and expenditure of time over the period of a year's fishing

in the area considered. This is of course a matter of primary importance from the commercial point of view.

In dealing with the commercial statistics of landings we do as a matter of fact commonly apply the landing per unit of fishing time over periods of a year, which incidentally are natural cycles in the life-history of the fish. It is calculated as a rule on total landings by vessels of a particular class divided by the total number of hours' fishing. It would be possible also, and in some respects preferable, to calculate it by months, and take an average of the monthly values. Actually, when fishing is large in amount and well distributed in time and space, the values obtained by either method are practically the same. The following example may be given:— In 1927 the average landing per 100 hours' fishing by British steam trawlers of all bottom fish from the North Sea was 141 cwts., calculated on total landings divided by total number of hours' fishing. The monthly values (in cwts.) of the landings per 100 hours' fishing were 127, 134, 151, 152, 153, 145, 136, 125, 130, 153, 144 and 135, giving an average value of 140.4 cwts. Taking a single rectangle, namely G6, which is well fished throughout the year, the landing per 100 hours' fishing was 89 cwts. calculated in the first way, and 88.5 cwts. calculated in the second way. It will be seen that the differences are insignificant.

Where the data are adequate, the landing per unit of fishing time even over a period of a year may accordingly safely be used as an index of the average abundance of the catchable stock, as affected by the amount of fishing and by all other modifying factors, such as the influx of new stock, and the growth of the fish. It is, mathematically speaking, an average of the landings per unit fishing time which have been made continuously throughout the year.

It is clear from this discussion that the primary condition for the validity of the catch (or landing) per unit fishing time is that the sampling shall have been adequate, having regard to the particular area and period considered. To get any broad and reasonably accurate picture of the comparative abundance of stocks over wide areas it is necessary to have at one's command accurate statistics of a large and well distributed fishery. Data which relate merely to a small and restricted fishery will be apt to give an inadequate and probably a misleading picture. Where an area is inadequately sampled, as for instance the Barents Sea in the early years of its exploitation, no great reliance can be placed on the value of the landings per unit fishing time.

There is a second condition of great importance, especially when comparisons are made over a long range of time, namely that the fishing power employed, as gauged by size of vessel, and type and catching

power of the gear employed, must have remained approximately constant during the period considered. This is a point of rather special interest, in view of the developments which have taken place since the war in the size and effectiveness of trawling gear. The general shift over from the ordinary otter trawl to the VIGNERON-DAHL trawl in one or other of its numerous modifications has undoubtedly made the interpretation of any changes in the landings per unit fishing time more difficult and uncertain. The general direction of the change due to this development of trawling gear is of course known, but its exact effect is difficult to estimate accurately, owing to the great diversity of types of trawling gear now in use.

A third point which must be taken into consideration in appraising the value of the landing per unit fishing time as an index of stock is the possible variation in the requirements of the market. The statistics relate to the quantities landed for sale; if the demand for fish grows the small fish previously rejected at sea as unsaleable may acquire a marketable value and be brought to port to swell the landings. So too, when we are considering the landings of all demersal fish taken together, and comparing the landings per unit fishing time over a series of years, our deductions may be affected by the fact that species previously discarded at sea are now brought to market, having acquired a marketable value. It is common knowledge that in the course of the last twenty years and more, several kinds of fish formerly rejected as of no commercial value have gradually come on the market, and so have helped to increase the landings per unit fishing time of total demersal fish.

The three conditions of validity mentioned are the most important, though other minor difficulties may arise, as everyone knows who has attempted to deal with fishery statistics. But if these three conditions hold good, or if the effect of any alterations in them can be allowed for, the landing per unit fishing time may be expected to afford a generally reliable index of the comparative abundance of the catchable stock, so far at least as weight is concerned.

It will be convenient and helpful at this stage to consider certain detailed objections raised by KYLE[1]) to the use of this measure of the relative abundance of the stock. Some of these objections are perfectly valid, and he has performed a useful service in emphasising the dangers of an uncritical use of this measure of abundance; we shall see, however, that his criticisms do not invalidate the use of the criterion, provided it be applied with due caution.

[1]) Die Statistik der Seefischerei Nordeuropas', Handbuch der Seefischerei Nordeuropas, Bd. X, Heft 4, Stuttgart, 1928.

He sets out to prove that the methods for determining the quantitative distribution of fish recommended by ARCHER (average catch per voyage, per hour, etc.) are inadequate, and can lead to no scientific conclusions (p. 23).

After referring to the landings per day's absence by German and English vessels in 1925 from the various Regions — which as a matter of fact show considerable agreement — he goes on:—

"From the English statistics for the same year the quantities per hour's fishing can also calculated, which give to a certain degree a still more accurate picture.

	kg per hour's fishing
Barents Sea	453
Iceland	521
North Sea	62
Channel	51
South of Ireland	125
Biscay	109

It appears therefore that the North Sea, in respect of its richness in fish, is not comparable with Iceland or the Barents Sea, since both of these yield 7—8 times as much fish per hour. It is, however, necessary to regard such figures with reserve.

The regions are for one thing not equally intensively fished: although for example the German and English data for the Barents Sea in respect of total catch agree with one another, the number of hauls is too small and limited to too few months for them to be regarded as representative.

In the second place, there may be great differences between the catches, when the areas are very large; thus the German catch, i. e. per day's absence, for the North Sea is considerably greater than the English, simply because the Germans fish relatively little in the North Sea, and then mostly in the best spots and in the best months, while about 600 English steam vessels are almost constantly at work in the North Sea.

Thirdly, if 600 vessels fish an area, their individual catches cannot be expected to be as high as when only 150 are at work. This is about the relation between the English fishery in the North Sea and in Icelandic waters. The North Sea is accordingly fished 4 times as intensively as the latter, and on this ground alone one might expect that the Icelandic catches would be at least twice as large as the North Sea catches.

Again, the catching power of the vessels is very different, and it is easily seen that the size of the catches increases with distance from the North Sea ports; that is to say the vessels are larger and have a greater

catching power. The Iceland steamers for instance catch at least 50 per cent. more than the ordinary North Sea steamers.

Fifthly, the choice which the fishermen find on the distant grounds affects the statistical data. As will be further shown below, the Germans bring very few plaice but many coalfish to their home markets, because they get in England a better price for their plaice but a worse price for their coal-fish than in Germany; this probably explains the lower German average catch shown for Icelandic waters.

These various difficulties and others to be mentioned later are here specially brought into prominence, because great importance has been attached to these factors. It has been thought that from such data conclusions can be drawn as to the exploitation (overfishing or otherwise) of an area, and so they can — but whether these conclusions are always valid is a matter for grave doubt" (pp. 24—25).

Of these five objections, all but the third are perfectly valid, and they have already been recognised in principle in our discussion above. The first, second, and fifth are merely particular instances of inadequacy of sampling, which would be looked for and allowed for by anyone having experience in the difficult art of treating fishery statistics. The fourth caveat is also one which we have specifically mentioned.

More interest, both theoretical and historical, attaches to the argument outlined in the third objection. It is here pointed out that the difference in the average landing per day's absence between Iceland and the North Sea is in part accounted for the fact that the North Sea is fished much more intensively — a perfectly correct conclusion. The amount of fishing is obviously one of the principal factors affecting the magnitude of S. During the War, the amount of fishing in the North Sea was greatly reduced and the l. p. d. a. from this area was in 1919 nearly double the pre-war average. Similarly, if the intensity of fishing in Icelandic waters were to be suddenly increased one would expect to find a diminution in the l. p. d. a. The l. p. d. a. is in fact a running index of the weight of commercially valuable stock left on the grounds, and one therefore expects it to be influenced by the actual amount of fishing, since fishing is one of the main factors in reducing stock. Accordingly KYLE's objection has no weight whatever against the validity of the l. p. d. a. as a comparative index of commercial stock remaining on the grounds. It gives an indication of the state of S as affected by the amount of fishing and by the other factors, G, M and A, which modify it. It does not purport to do more.

I said above that the question was one of historical, as well as theoretical interest. I had in mind the important evidence given by GAR-

STANG so long ago as 1904 before a Hourse of Lords Committee[1]) in which he expressed the opinion that "it is impossible merely from the evidence of the decline in the average catch of the fishermen with an increasing number of boats to conclude that there has been an improverishment of the grounds". He has recently discussed the question again in a most interesting way in his third Buckland Lecture[2]) and has come to the conclusion that the average catch is not invalidated as a measure of abundance. "It registers the abundance truly enough, and when it falls with an increase in the intensity of fishing, it does so because, pending replenishment, there is greater depletion, the greater the rate of capture; and there is an inevitable lag in the process of replenishment" (p. 29).

The factor of replenishment is of course in practice extremely important — as indicated in our general formula by G and A — but the catch per unit time would be valid even if we supposed this factor to be absent.

At the risk of being tedious, let us consider this point again. Let us imagine an area of limited size, populated by a stock of catchable fish of a certain definite number and evenly distributed over the area. We shall assume, in order to simplify the case as much as possible, that this stock is not added to by the introduction of new stock growing up. Let us consider what will happen if this stock is fished (1) by 10 vessels, or (2) by 100 vessels, of equal size and fishing power, over the same period of time, say one month. If our original assumption is correct, that a vessel with standard gear, fishing under standard conditions, takes on the average a fixed proportion of the catchable fish present on the ground covered, then it is apparent that in the first few hours of fishing the catch per hour will be practically the same for the 100 vessels as for the 10 vessels. But the 100 vessels will take more away from the stock than the 10 vessels; hence in case (2) the catch per hour will fall at a greater rate than in case (1), and by the end of the month the catch per hour by the 100 vessels will be definitely less. The average catch per hour over the whole of the month will also be less for the 100 vessels than for the 10. This difference indicates that the stock at the end of the period is less when 100 vessels have been fishing than when only 10 vessels have been at work — which is self-evident. The point is in fact so elementary as hardly to require proof. But it does bring out the cardinal fact that the average catch per hour at any particular

[1]) Report on Sea Fisheries Bill (H. L.), London, H. M. Stationery Office, 1904, p. 115.

[2]) The Fishing News, Aberdeen, Vol. XVIII, No. 888, June 7th, 1930.

time is an index of the stock remaining on the ground at that time. Taken over a period of time, the catch per hour indicates the average state of the stock during the period, as affected by the amount of fishing going on.

The catch per unit of fishing time is clearly affected by the amount of fishing which is being carried on contemporaneously. But this is simply because the amount of the stock is being affected by the amount of fishing, which again is self-evident.

KYLE in the paper referred to above appears to think that this characteristic of the catch per unit time invalidates its use as an index of stock. He apparently argues as follows. If we compare an area during a period when fishing has been slight with the same area during a period of intensive fishing, and find that in the second period the catch per unit time is less, we cannot conclude that the stock has diminished in the second period as compared with the first — it may simply be that a stock of the same size as the original stock has been shared out among a larger number of vessels. The argument is perfectly sound up to a point, but it does not take all the facts into account. It is true only as regards the stock to start with, before fishing operations have begun. In illustration, let us take our case of the 10 and the 100 vessels, and let us assume that the stock on which the 100 vessels set to work is not necessarily the same in magnitude as the stock fished by the 10. If the catch per unit time by the 100 vessels is less than that by the 10 we cannot infer that the stock to start with was less — it may have been equal to, or even greater than, the original stock which the 10 vessels started to exploit. Hence a difference in the catch per unit time does not *per se* indicate a corresponding difference in original stock.

But the decreased catch per unit time by the 100 vessels does indicate that the final and the average magnitude of the stock, under the influence of fishing, was less than when the 10 were fishing. That is all it can show, but it is quite sufficient for all practical purposes. We rarely encounter a case where we can speak of an original stock prior to fishing. The nearest approach to such a case is when large shoals of fish approaching the shore in a body become the object of a coastal fishery, as in the Norwegian cod fishery. If in such a fishery there are large fluctuations in the amount of fishing from year to year it is difficult or impossible to draw conclusions merely from changes in the catch per boat per unit time as to the relative abundance of the successive yearly stocks, as they come in, before they have been affected by fishing.

In actual practice, however, in dealing with the modern trawl-

fishery, which is in most areas both intensive and continuous, the question of "original" stock simply does not arise; we have to deal with stocks which are constantly and considerably being reduced by fishing operations, and the catch per unit time shows us sufficiently well what is actually taking place. Under present-day conditions, fishing is one of the most potent factors affecting the magnitude of stocks, and our index, the catch per unit time, takes account, and rightly, of this as well as of the other factors concerned. The amount of the stock is as we have seen, a constantly fluctuating one, depending upon the amount of fishing, the rate of natural mortality, influx of new stock, and rate of growth — as indicated in our elementary formula. As we have to deal with actualities, with stocks subjected constantly to intensive fishing, it is of little interest to speculate as to what the state of stocks would be if this factor were eliminated, or reduced to what is was twenty, thirty or fifty years ago. What we have to study are the changes in S under the present conditions of intensive fishing, and our best guide to these changes is the catch or landing per unit fishing time.

Kyle prefers as an index of productivity the total yield of fish, but makes no attempt to relate this with catching power, — although it is obviously in the main a function of the amount of fishing, — for the reason that total catching power cannot be estimated accurately. Overfishing will be indicated, he considers, if there is a progressive diminution in quantity or quality of the total yield over a period of years — "If in a long series of years the yearly quantities decrease, or if the quality becomes constantly poorer, we can then say that the productivity of the area in fish is too small for the intensity of the fishery" (pp. 29—30).

Total yield is undoubtedly a most important datum, corresponding approximately to C in our elementary formula, but it gives merely what is taken out, and affords no indication of what is left in the sea. For an index of remaining stock it is absolutely necessary to have recourse to some index relating catching power to weight of catchable fish on the ground. The catch or landing per unit fishing time can, if certain conditions be fulfilled, be used as such a measure or index.

Biological statistics regarding the Herrings along the Baltic coast of Sweden.

By

Chr. Hessle, Stockholm.

Along the Baltic coast of Sweden there are four different herring races viz. autumn spawning sea herrings, spring spawning sea herrings, ice herrings and fjord herrings[1]). Of these races the autumn spawning and the spring spawning sea herrings are of the greatest economic value. The ice herrings are of some importance only along the coast of the Gulf of Bothnia and the fjord herrings are only fished for in certain strictly limited areas (mostly closed fjords) on the coast of the Middle Baltic.

Ordinarily the autumn spawning sea herrings constitute the main part of the total annual catch of the Baltic herrings, and the fluctuations of the herring fishery in the Baltic are usually chiefly dependent upon the greater or smaller abundance of this race, as I pointed out in a paper published in this Journal (vol. II, no. 2, 1927). I then stated that the fishery during the years 1921—1925 had been based mainly on the year classes of 1917, 1918 and 1922 of this race, whilst the year classes of 1919, 1920, 1921 were obviously very weak. Our investigations have also shown that the fluctuations of the relative strength of the different year classes have been about the same in different parts of the Baltic, which is remarkable considering the very different climatic and hydrographic conditions in different areas of this sea.

During the last three years we have continued these investigations and the diagrams in fig. 1 give a survey of the percentage of the different year classes of the autumn spawning sea herrings during 1927, 1928 and 1929. As will be seen the year classes of 1917, 1918, as well as that of 1922, were already of comparatively little importance by 1927. Only in the Gulf of Bothnia the year class of 1922 still played a more

[1]) Chr. Hessle. The Herrings along the Baltic coast of Sweden. Publ. de Circ. No. 89, 1925.

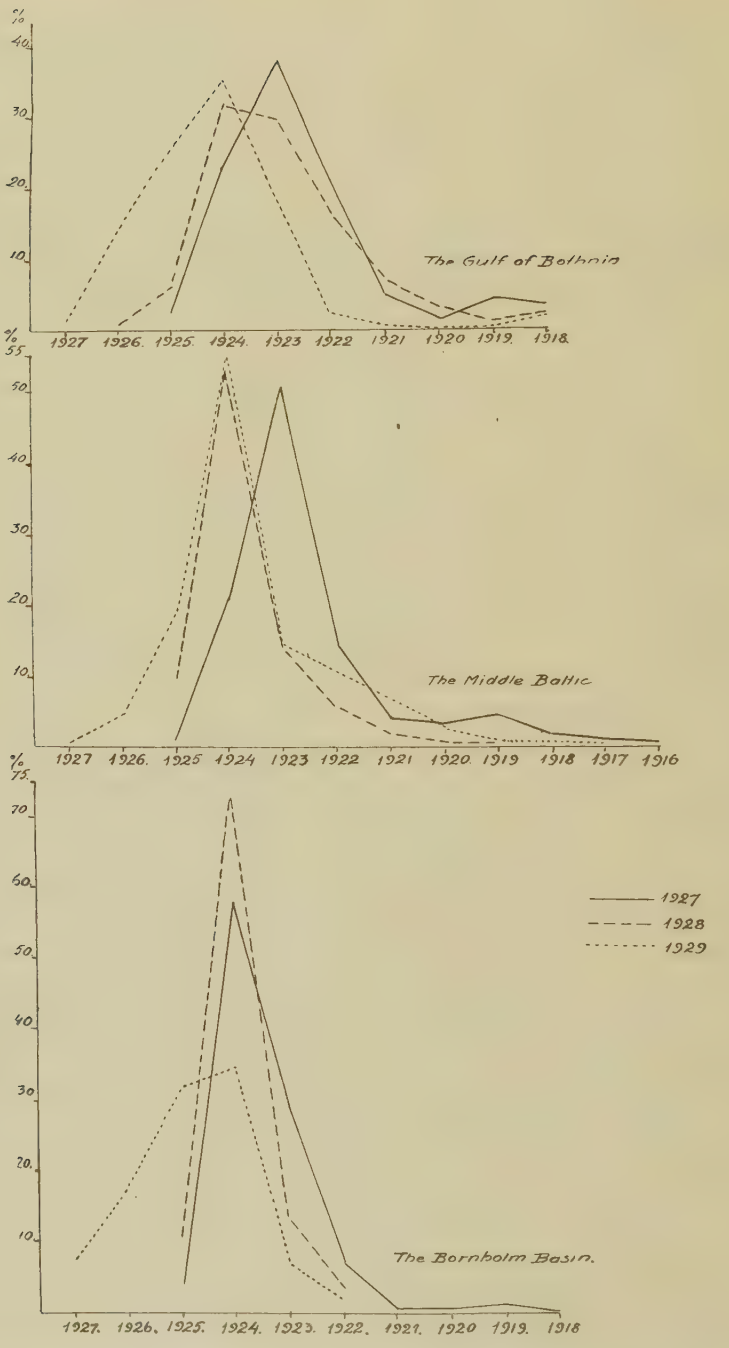

Fig. 1. Percentage of the different year classes of the autumn spawning sea herrings in catches during 1927, 1928 and 1929 from the Gulf of Bothnia, the Middle Baltic and the Bornholm Basin.

prominent part in the total catch as late as 1927. I have already pointed out in 1927 that the older year classes always seem to be better represented in the catches from the Gulf of Bothnia than in the catches from the areas south of this district. It is consequently of interest to notice that even if the year classes of 1917 and 1918 were on the whole of little importance in the total catch in the Gulf of Bothnia during 1927, these year classes, at least in some localities, were still rather abundant during this year. Thus a sample from 1927 from Bjurö klubb in the northern part of the Gulf of Bothnia contained not less than about 71 % of herrings hatched during the years 1917 and 1918.

Even if older year classes were comparatively well represented in the Baltic catches during 1927, the main part of the autumn spawning sea herrings in these catches consisted of herrings belonging to the year class of 1923. This was at least the case in the Gulf of Bothnia and in the Middle Baltic. In the Bornholm Basin this year class never seems to have been of any great importance and by 1927 it was less abundant in the catches from this area than the year class of 1924. This, in fact, is also the only time we have found that the dominating year class has not been the same along the whole Baltic coast of Sweden.

Even if, as stated above, the year class of 1923 predominated among the autumn spawning sea herrings in the middle and northern parts of the Baltic during 1927, this year class must nevertheless have been comparatively weak, because by 1928 this year class everywhere in the Baltic had lost its dominating position in the catches. During 1928, as well as 1929, the year class of 1924 played the greatest part in the catches. During 1929 the year class of 1925 was comparatively well represented in the catches of the autumn spawning herrings, especially in the Bornholm Basin and in the Gulf of Bothnia. Consequently it seems very possible that this year class will predominate during 1930.

According to our investigations the fishery of the autumn spawning sea herrings during the years 1921—1929 has been based mainly on the year classes of 1917, 1918, 1922, 1923 and 1924. Among these year classes those of 1917 and 1918 were certainly the strongest, as the herring fishery was based chiefly on them for four or five years. The year class of 1923 was comparatively weak, as one can conclude from the fact that it did not predominate for more than one year and this only along the northern and middle part of the coast. Below I hope to be able to explain that the year class of 1924 was also fairly weak.

The spring spawning sea herrings are generally caught together with the autumn spawning sea herrings. In ordinary years the spring spawning sea herrings are of some economical value only in the Middle Baltic,

especially outside those coasts of this area where archipelagos occur. In the southern part of the Baltic and around the islands Öland and Gotland in the Middle Baltic this race generally plays a rather inconsiderable part. We have not been able to find out if this race exists at all in the Gulf of Bothnia. In this district there are also, it is true, spring spawning herrings but they seem generally to belong to another race "the ice herring".

The percentage of the spring spawning and the autumn spawning herrings in catches during the last five years will appear from table 1. The table shows that the spring spawners during 1925—1928 were as

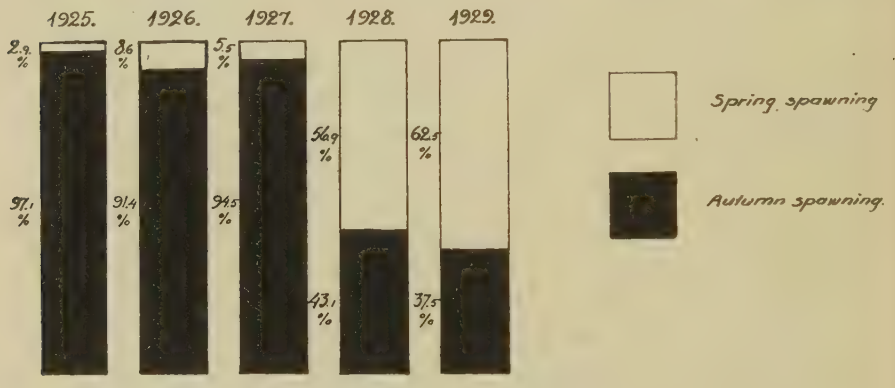

Fig. 2. Percentage of spring spawning and autumn spawning herrings in catches from the Middle Baltic during each of the years 1925—1929.

usual very scarce in the Bornholm Basin. During 1929 they seem, however, to constitute not less than 31.2 % of the total catch. Unfortunately we have only one sample from this district during 1929. It is consequently impossible to discern how great the percentage of the spring spawners really was in this district during that year. The sample indicates, however, that the spring spawners must have been exceptionally numerous in the Bornholm Basin during 1929.

In the Middle Baltic the average percentage of the spring spawners in the catches was far below 10 % during the years 1925—1927. During 1928, however, the percentage of this race had increased to not less than 56.9 % and during 1929 the importance of the spring spawners was obviously still greater, as they then constituted as much as 62.5 % of the total catch in the Middle Baltic (fig. 2). Consequently the spring spawners show a very remarkable increase in the Bornholm Basin as well as in the Middle Baltic. This increase first became visible in the catches in the Middle Baltic in 1928, but in the Bornholm Basin not

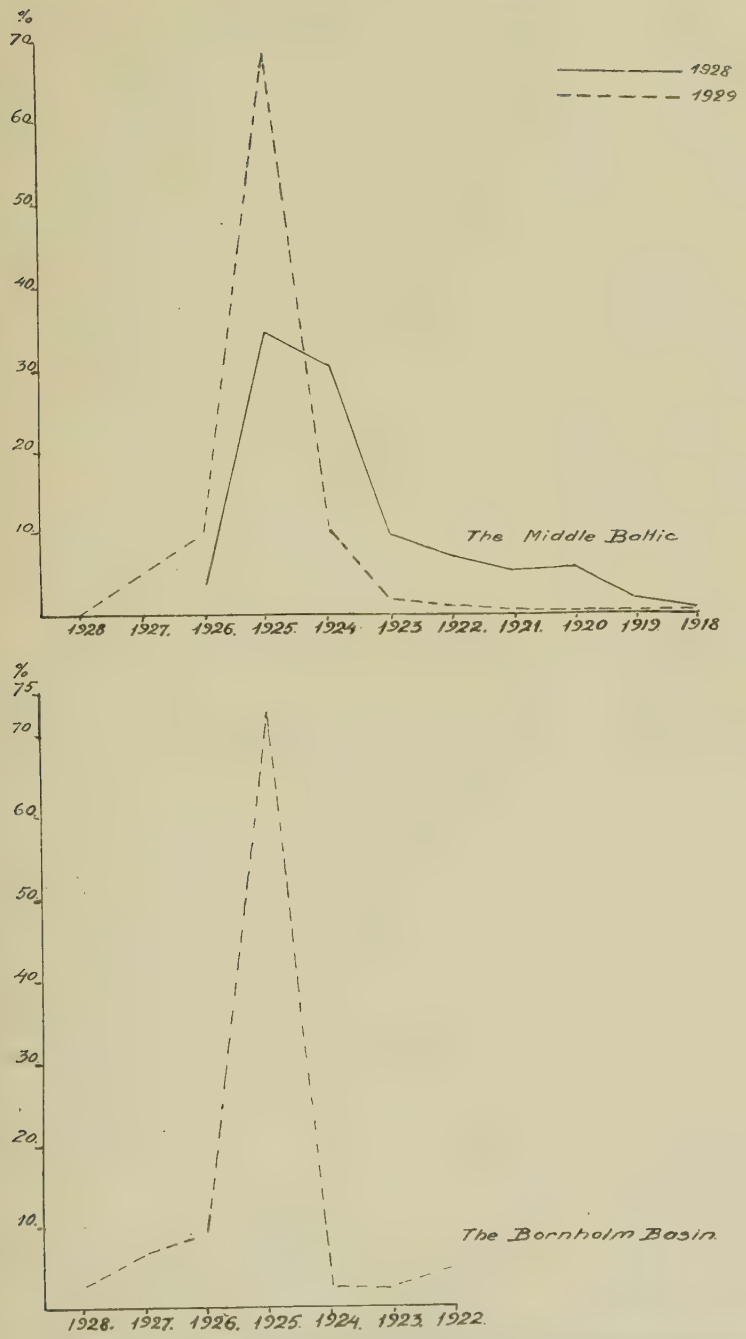

Fig. 3. Percentage of the different year classes of the spring spawning sea herrings in catches during 1928 and 1929 from the Middle Baltic and the Bornholm Basin.

until 1929. It is not quite clear why the spring spawners were comparatively more numerous in the catches in the Middle Baltic than in the Bornholm Basin during 1928. It is, however, possible that this is partly due to the fact that the mesh of the drift nets used in the Bornholm Basin is larger than that of the nets in the Middle Baltic. Our samples indicate that the increase of the spring spawners principally depends on a single rich year class hatched in 1925, and it is possible that during 1928 the bulk of this year class in the Bornholm Basin had not yet attained a sufficient size to be caught in the nets as the spring spawning sea herrings at an age of four or five years have a length which is about 1 cm. less than that of the autumn spawning herrings.

As already mentioned, the great increase of the spring spawners seems to be due principally to the strong year class of 1925. This was obviously strongly predominant in the Middle Baltic as well as in the Bornholm Basin, as will clearly appear from the diagrams in fig. 3. The same figure also shows, however, that the year class of 1924 was comparatively strong in the Middle Baltic as this year class during 1928 constituted about 31 % of the total catch of the spring spawners in this area. This year class was, on the other hand, very scarce in the catches in the Bornholm Basin. Consequently it is possible that the lower percentage of spring spawners in the catches in the Bornholm Basin during 1928 is also due to a weaker year class of 1924 in this area than in the Middle Baltic.

As stated above, the spring spawners have increased very much in the Middle Baltic and the Bornholm Basin, probably chiefly as a consequence of a strong year class of spring spawners hatched in 1925. A glance at table 1 shows that no such increase has taken place in the Gulf of Bothnia. In this area the spring spawners even in 1928 and 1929 only constituted a small percentage. As I have already pointed out, the spring spawners in this area belong to a race, "the ice herrings", other than the spring spawners in the Middle Baltic and the Bornholm Basin, of which at least the majority belong to the "spring spawning sea herrings". The ice herrings and the spring spawning sea herrings

Table 1. Percentage of autumn spawning and spring spawning

Area	1925			1926	
	antumn spawning	spring spawning	No. of ind.	autumn spawning	spring spawning
The Bornholm Basin	95.9	4.1	295	92.1	7.9
The Middle Baltic	97.1	2.9	844	91.4	8.6
The Gulf of Bothnia	—	—	—	89.3	10.7

both spawn chiefly in June. But whereas the spring spawning sea herrings spawn in comparatively deep water on the coastal slope outside the archipelagos, the ice herrings spawn in shallow water and very often inside the archipelagos. It may perhaps be the different situations of the spawning places that has caused the great difference in the result of the spawning during 1925 between the ice herrings and the spring spawning sea herrings, but it is of course also possible that the factors which were favourable for the spawning and development of the fry, which obviously were present in the Middle Baltic and the Bornholm Basin during 1925, did not then prevail in the Gulf of Bothnia.

As mentioned above, the autumn spawning sea herrings during ordinary years constitute the main part of the total catch along the whole Baltic coast of Sweden. The predominating year class of the autumn spawning sea herrings is then also predominant in the total catch. This was, however, not the case during 1929 in the Middle Baltic and the Bornholm Basin. In the Bornholm Basin the autumn spawning sea herrings only constituted about 68.8 % of the total catch and of this percentage only 34.1 % belonged to the predominant year class of 1924. Consequently in this area the strongest year class of the autumn spawning herrings (that of 1924) did not constitute more than about 23.5 % of the total catch, and in the Middle Baltic the same year class of the autumn spawners only constituted about 20.5 % of the total catch. As the fishery in the Middle Baltic as well as in the Bornholm Basin seems to have been about average during 1929 (definite figures not yet available) one must then conclude that the year class of 1924 of the autumn spawning sea herrings at least in the Middle Baltic must have been very weak in comparison to earlier predominant year classes of this race. The fishery in the Middle Baltic and the Bornholm Basin evidently owes its fairly good result to a great extent to the rich year class of 1925 of the spring spawners. This one can also conclude from the fact that the herring fishery in the Gulf of Bothnia, which was based almost solely on the autumn spawners, as the spring spawners there were very scarcely represented in the catches, was far below the average during 1929.

m different areas of the Baltic during each of the years 1925—1929.

1927		1928			1929		
spring spawning	No. of ind.	autumn spawning	spring spawning	No. of ind.	autumn spawning	spring spawning	No. of ind.
1.7	232	95.3	4.7	150	68.8	31.2	141
5.5	600	43.1	56.9	202	37.5	62.5	1293
7.5	322	89.0	11.0	300	87.8	12.2	238

Zum Rassenproblem bei den Fischen[1]).

Von

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Seit dem Erscheinen von Heincкes grosser Arbeit, deren Ergebnis darin gipfelte, dass beim Hering eine grössere Zahl von Rassen vorhanden sind, deren morphologische Merkmale erblich sind, haben sich die Ansichten der Autoren, die sich weiterhin mit diesem Problem beschäftigten, teilweise recht wesentlich von der Auffassung Heincкes entfernt. Vor allen Dingen ist es die Ansicht von der Inkonstanz der Rassenmerkmale, von der weitgehenden Abhängigkeit ihrer Entwicklung von äusseren Einflüssen, die in starkem Gegensatz zur Auffassung Heincкes steht. Dabei geht der extreme Standpunkt so weit, das Vorhandensein von Rassen überhaupt zu leugnen und alle Variabilitätserscheinungen auf die Einflüsse von Aussenfaktoren zurückzuführen. Eine gemässigte Richtung hingegen erkennt wohl das Vorhandensein von Rassen an, gibt auch bis zu einem gewissen Grade die Erblichkeit der Merkmale zu, räumt aber doch den Aussenfaktoren mehr oder weniger starke modifizierende Einflüsse auf die Entwicklung der Rassenmerkmale ein.

Bei dieser Lage der Dinge ist es zunächst unbedingt notwendig, bevor man die eigentlichen Rassenanalysen weiter durchführt, die grundsätzlichen Fragen nochmals eingehend zu prüfen, die Fragen nach dem Wesen der Rassen, dem Wert oder Unwert der Merkmale, der Möglichkeit modifizierender Einwirkungen u. ä.

Ergibt eine Nachprüfung, dass die Merkmale, die man bisher zur Unterscheidung von Rassen herangezogen hat, nicht unbedingt erblich sind, sondern so plastisch, dass sie nach den jeweiligen örtlichen oder

[1]) Die Hauptarbeit erscheint in: Zeitschr. f. wiss. Biol. Abt. A, Zeitschr. f. Morphol. u. Ökol. d. Tiere. Verl. Jul. Springer, Berlin.

zeitlichen Einwirkungen der Aussenfaktoren merklichen Änderungen unterworfen sind, so sind diese Merkmale als Rassenmerkmale vollkommen ungeeignet, und die Träger dieser Charaktere sind keine echten Rassen. Man müsste hierfür eine besondere Bezeichnung prägen, um dadurch gleich den grundsätzlichen Unterschied gegenüber den echten Rassen zum Ausdruck zu bringen. Für eine geographische Rasse (Geotyp) ist unbedingte Voraussetzung die Erblichkeit der für sie charakteristischen morphologischen Merkmale. Ist diese Vorbedingung nicht erfüllt, so ist die Bezeichnung geographische Rasse unzulässig. Das ist eine Auffassung, die heute in der allgemeinen Rassenforschung als Grundsatz gilt.

Bei der immer wieder innerhalb der Fischereibiologie so stark betonten Auffassung von der Veränderlichkeit der Rassenmerkmale haben wir zunächst zu prüfen, welche Begründungen hierfür angeführt werden und werden können, und ob diese einer Kritik standhalten.

Versuche, die Entwicklung von Organismen durch Veränderung der einwirkenden Faktoren zu beeinflussen, sind in reichem Masse gemacht. Ihre Ergebnisse zeigen, dass es durchaus möglich ist, die Entwicklungstendenz abzulenken. Daraus aber zu schliessen, dass jeder Organismus und jedes Organ immer und unter allen Umständen durch Veränderungen und Schwankungen in den Aussenbedingungen in ihrer Entwicklung und endgültigen Gestaltung modifizierend beeinflusst würden, wäre falsch. Alle die Versuche, die mit abnorm veränderten Bedingungen arbeiten oder mit solchen, wie sie in der Natur nicht vorkommen, scheiden von vornherein für allgemeine Schlussfolgerungen aus. Aber auch die übrigen sind nicht geeignet, als Grundlage für eine allgemeingültige These zu gelten.

Die Abweichungen, die bei diesen Versuchen erzielt wurden, sind durchweg qualitativer Art (Entwicklungsschnelligkeit, Wachstumsform, Pigmentierung u. ä.), die für die Rassenuntersuchungen an Fischen in erster Linie benutzten Merkmale sind dagegen quantitativer Art (Skelettelemente). Die Entwicklung qualitativer und quantitativer Merkmale ist aber verschieden. Die Möglichkeit einer Einwirkung von Aussenfaktoren ist wesentlich abhängig von der erblichen Festigung und der Entwicklungszeit der einzelnen Merkmale. Wie es konstante und labile Arten gibt, so gibt es auch konstante und labile Merkmale. Allgemeine Schlussfolgerungen vom Einen zum Anderen zu ziehen, ist nicht angängig.

Zu einem Urteil über die Reaktionsfähigkeit der Rassenmerkmale bei den Fischen ist es deshalb notwendig, diese Merkmale in ihrer Entwicklung genauer zu untersuchen. Das ist in einer bereits veröffentlichten

Arbeit geschehen[1]). Diese Untersuchungen haben ergeben, dass die beim Hering für die Rassenanalyse benutzten Merkmale betreffs der Reaktionsmöglichkeit ganz verschieden beurteilt werden müssen. Die Entwicklung der Wirbelsäule, des für die Rassenuntersuchungen wichtigsten Merkmales, bietet die geringste Möglichkeit für eine modifizierende Beeinflussung, weil bei der Wirbelsäule, die in ihrer Unterteilung streng metamer ist, die Gliederung bereits sehr früh in der Entwicklung abgeschlossen ist. Die Zeitspanne, während der eine Einwirkung möglich sein könnte, ist äusserst gering.

Die Entwicklung der Flossen verläuft anders, teilweise ist ihre Entwicklungsspanne sehr lang, und die Möglichkeit besteht, dass die Anlagen einzelner Elemente nicht oder nicht voll zur Entwicklung kommen, dass andere, ursprünglich gehemmte, später aktiviert werden. Da die endgültige Lage des Afters und der Bauchflossen bis zu einem gewissen Grade von Wachstumsvorgängen abhängig ist, kann auch bei der Unterteilung der Kielschuppen die Möglichkeit einer Beeinflussung vorliegen.

Bei der Vornahme variationsstatistischer Untersuchungen an Fischen sind nun bisher fast immer die etwa auftretenden Unregelmässigkeiten auf Schwankungen bei den Aussenfaktoren während der Entwicklung zurückgeführt. Nur in einzelnen Fällen ist der Versuch gemacht zu prüfen, ob die Unregelmässigkeiten auch auf andere Weise zu erklären sind. Prüft man nun die einzelnen Fälle nach, die als Beweis für die Einwirkung jährlicher oder örtlicher Schwankungen angeführt sind, so lässt sich nachweisen, dass die Schlüsse nicht zwingend sind. In den meisten Fällen lassen sie sich auf Durchmischungen zurückführen, die als solche nicht erkannt sind. In anderen Fällen sind die Unregelmässigkeiten durch quantitativ ungleichmässiges Material hervorgerufen. Man kann keine gleichmässigen Ergebnisse erwarten, wenn man beispielsweise Proben von 200, 100, 50 und 20 Individuen miteinander vergleicht. Eine kritische Nachprüfung einzelner Fälle, wie sie in der Hauptarbeit durchgeführt ist, muss hier unterbleiben, da sie eine zu sehr ins Einzelne gehende Darstellung verlangt.

Sehr wesentlich zu der Auffassung von der Labilität der Merkmale beigetragen haben die eigens zur Prüfung dieser Frage an Fischen angestellten Versuche. Gewiss sind die Ergebnisse dieser Versuche in hohem Grade beachtlich, aber sie sind nicht eindeutig genug und vor allen Dingen keineswegs geeignet, als allgemeingültig angesehen zu werden. Die Viviparität und die damit im Zusammenhang stehende Paarung der

[1]) Ber. d. Deutsch. wiss. Komm. f. Meeresf. Bd. V, H. 2.

Elterntiere, wozu bei *Zoarces* noch der ganz ausgeprägte Standfischcharakter kommt, schaffen für die Versuchstiere ganz besondere Verhältnisse, die der Kombination der Erbanlagen, dem Einfluss der Biotypen, der Einwirkung des mütterlichen Organismus auf die Entwicklung besondere Bedeutung geben, die nicht in gleicher Weise auf alle Fische zu übertragen ist. Es ist bei diesen Versuchen auch nicht scharf genug zwischen individueller und transindividueller Einwirkung geschieden. Die zu diesen Versuchen verwandten Fische sind in biologisch-physiologischer Hinsicht so ganz anders geartet als diejenigen, an denen sonst bisher Rassenuntersuchungen gemacht sind. Es sei auch darauf hingewiesen, dass bei *Zoarces* mehrere Jahrgänge einer Rasse wohl Schwankungen zeigen, dass diese aber angesichts der aussergewöhnlich starken Variabilität dieses Fisches — ausserdem wird hier auch noch der Einfluss der Biotypen mitwirken — nicht so gross sind, dass sie besonders beweisend wirken können, zumal teilweise die Schwankung innerhalb eines Jahrganges grösser ist als zwischen mehreren Jahrgängen.

Diese Versuche beweisen also bestenfalls, dass unter besonderen, von den normalen Daseinsbedingungen abweichenden Einflüssen Entwicklungshemmungen, Entwicklungsstörungen, Ablenkungen in der Entwicklung, je nach der Wirkungsfähigkeit und Reaktionsstärke der einzelnen betroffenen Individuen und Eigenschaften, eintreten können.

Das ist aber nicht der Kernpunkt, um derentwillen diese Untersuchungen angestellt sind. Die Kernfrage ist die, ob bestimmte morphologische Merkmale innerhalb einer Fortpflanzungsgemeinschaft so konstant sind, dass sie, unbeeinflusst durch die normalen Schwankungen der äusseren Bedingungen im Verbreitungsgebiet der betreffenden Fortpflanzungsgemeinschaft, als feste Charaktermerkmale angesehen werden können. Diese Frage ist in erster Linie zu prüfen.

Die für Rassenuntersuchungen verwandten Merkmale bedürfen betreffs ihres Wertes und ihrer Eignung zur Diagnose einer kritischen Betrachtung. Die vielfach noch immer benutzten Bauchflossen können bei den Rassenuntersuchungen ohne Gefahr unberücksichtigt bleiben, da ihre Variabilität zu gering ist, als dass man nach diesem Merkmal Rassen unterscheiden könnte. Geringe Variabilität zeigen ebenfalls Rücken- und Afterflosse, aber die Hauptschwierigkeit liegt bei diesen beiden Flossen in der grossen Gefahr persönlicher Fehler bei der Feststellung der Strahlenzahl.

Diese Gefahr besteht in gewissem Grade auch bei den Kielschuppen zwischen Bauchflossen und After, deren Abgrenzung nach vorn durchaus nicht immer eindeutig ist. Trotzdem darf aber der Wert dieses Merk-

mals nicht ganz von der Hand gewiesen werden. Auch die Unterteilung der Wirbelsäule in den Teil mit offenen und den mit geschlossenen Hämalbögen ist wohl zu berücksichtigen, doch scheinen nach den vorliegenden Erfahrungen bei der Bestimmung dadurch Fehler entstehen zu können, dass vielfach der erste Hämalbogen so dünn und zart ist, dass er bei der Präparation abbricht. Ungeachtet der genannten Bedenken sind aber die Merkmale K_2, Vert. praeh. und Vert. haem. mit zu verwerten, da sie in Zweifelsfällen, besonders bei Durchmischungen, mit Erfolg zur Entscheidung herangezogen werden können.

Das bisher wenig benutzte Merkmal der Strahlenzahl der Brustflossen sollte unbedingt mehr beachtet werden. Am sichersten zu bestimmen ist aber die Gesamtzahl der Wirbel, und in den meisten Fällen kommt man auch mit diesem Hülfsmittel aus, wo das nicht der Fall ist, müssen die Unterteilung der Wirbelsäule, Kielschuppen oder Brustflossen zur Entscheidung herangezogen werden. Es soll damit nicht gesagt sein, dass die Wirbelzahl *de facto* das einzige Merkmal einer Rasse ist. Unterschiede mögen noch in manchen anderen Merkmalen vorhanden sein, nur sind sie nicht immer leicht und einwandfrei bestimmbar. Das ist aber bei den Wirbeln der Fall, und sie bilden deshalb ein bequem benutzbares Merkmal für praktische Rassenuntersuchungen.

Nicht ausreichend ist hingegen die bisher benutzte Methode der Berechnung von Mittelwert und Standardabweichung. Gewiss kommen auch in den Mittelwerten die Unterschiede zum Ausdruck, aber doch nicht immer genügend scharf. Auch lassen sie Durchmischungen meist nicht richtig erkennen. Da hilft allein die Berechnung der prozentualen Häufigkeit und das dadurch gewonnene Kurvenbild, das für eine Rasse charakteristisch ist und Beimischungen erkennen lässt, oft sogar nach Art und Stärke.

Um zu zeigen, wie viel deutlicher in den Kurvenbildern charakteristische Unterschiede zum Ausdruck kommen als durch Mittelwerte, sei folgendes Beispiel angeführt: In dem Gebiet vom Fladengrund bis in die südwestliche Nordsee zeigen die Proben von Norden nach Süden ganz allmählich ansteigende Mittelwerte: 56.36, 56.45, 56.51, 56.53, 56.57, 56.62, 56.62, 56.76, 56.77. Aus solchen Zahlen kann geschlossen werden und ist auch geschlossen worden, dass keine festen Rassenmerkmale vorhanden sind, und es ist nicht möglich, auch nicht mit Hülfe der Standardabweichungen, eine Entscheidung zu treffen, ob und wo hier Grenzen zwischen einzelnen Rassen liegen. Die prozentualen Häufigkeitskurven (Abb. 1) aber geben ein viel deutlicheres Bild. Sie zeigen zwei grundsätzlich voneinander verschiedene Extreme, von denen die eine Form (die beiden unteren Kurven, den Mittelwerten

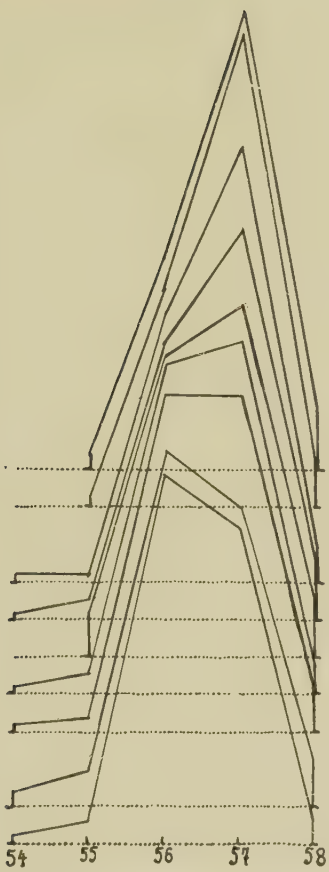

Abb. 1. Proz. Häufigkeitskurven des Merkmals Vert. S. als Beispiel für ihre Verwendung zur Erkennung von durchmischten Proben. Aus dem Gebiet Fladengrund (unten) bis Hoofden (oben), Mitte Doggerbank. Unten 2 Kurven vom Bankhering, oben 2 Kurven vom Kanalhering. Die mittleren Kurven zeigen Durchmischungen verschiedenen Grades.

Fig. 1. Percentage frequency curves of Vert. S. The two uppermost curves show the typical form of the Channel-herring (from the South-Western North-Sea), the two undermost the typical form of the Bank-herring (from the Fladen Ground). The 5 intermediate curves represent mixtures of both forms in different proportions (from the Dogger bank).

56.36 und 56.45 entsprechend) vom Fladengrund stammt, die andere (die beiden oberen Kurven, Mittelwerte 56.76 und 56.77) aus der südwestlichen Nordsee. In diesen beiden Gegensätzen kommen typische Merkmale von zwei Rassen zum Ausdruck, vom Bankhering (untere Form) und Kanalhering (obere Form), während die dazwischen liegenden

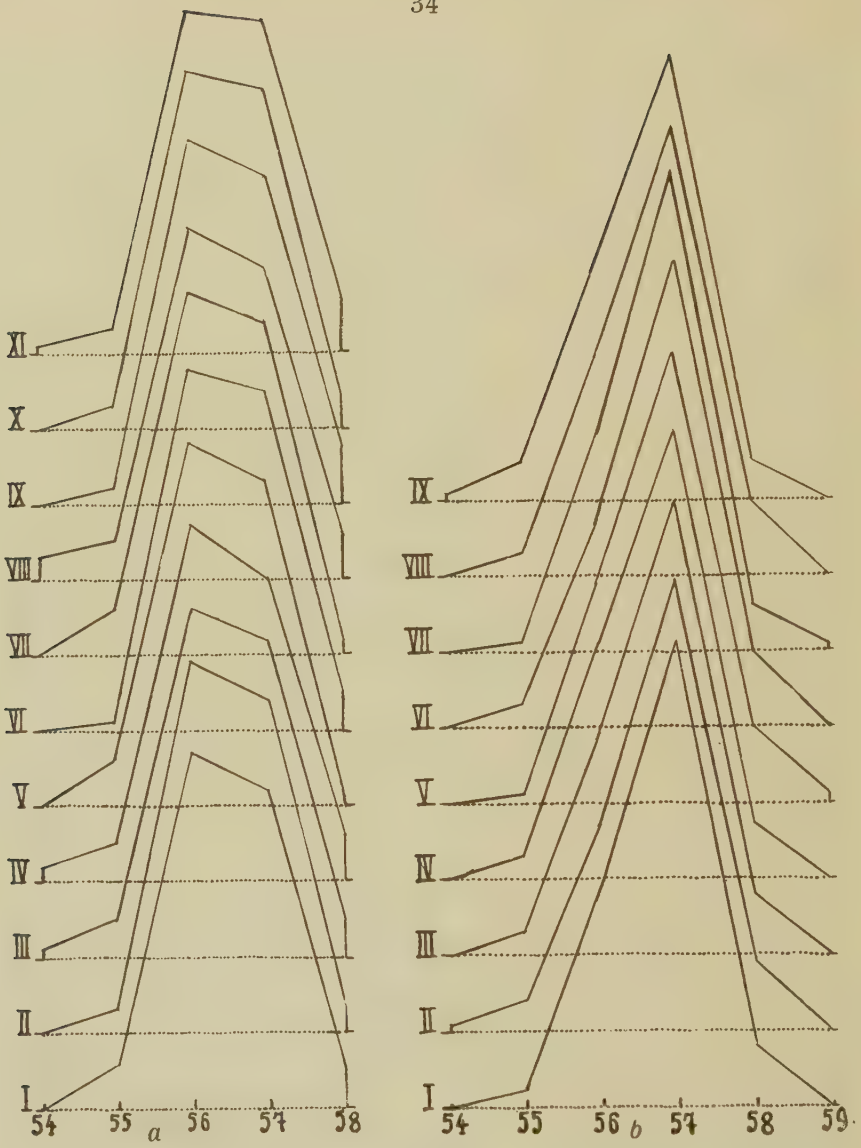

Abb. 2. Proz. Häufigkeitskurven des Merkmales Vert. S beim Bankhering (a) und Kanalhering (b).

a. I. Fair Island 1887 (Heincke).
II. Doggerbank 1906 (Redeke).
III. — 1924—25
IV. — 1926
V. — 1927
VI. Jungheringe aus der inneren Deutschen Bucht 1924.
VII. desgl. 1925.
VIII. Jahresklasse 1919.
IX. — 1920.
X. — 1921.
XI. — 1922.
(Schnakenbeck)

b. I. Proben aus den Jahren 1914-15 (Orton).
II. SW-Nordsee 1923 (Schnakenbeck).
III. Jugendl. Heringe aus d. Oster-Schelde 1926—27 (Tesch).
IV. Sandettie Fsch. 1927 (Schnakenbeck).
V. Boulogne 1928—29 (le Gall).
VI. Jugendl. Heringe v. Bruceys Garden 1928.
VII. Plymouth 1929.
VIII. Jugendl. Heringe v. Plymouth 1929.
IX. Jahresklasse 1920.
(Schnakenbeck)

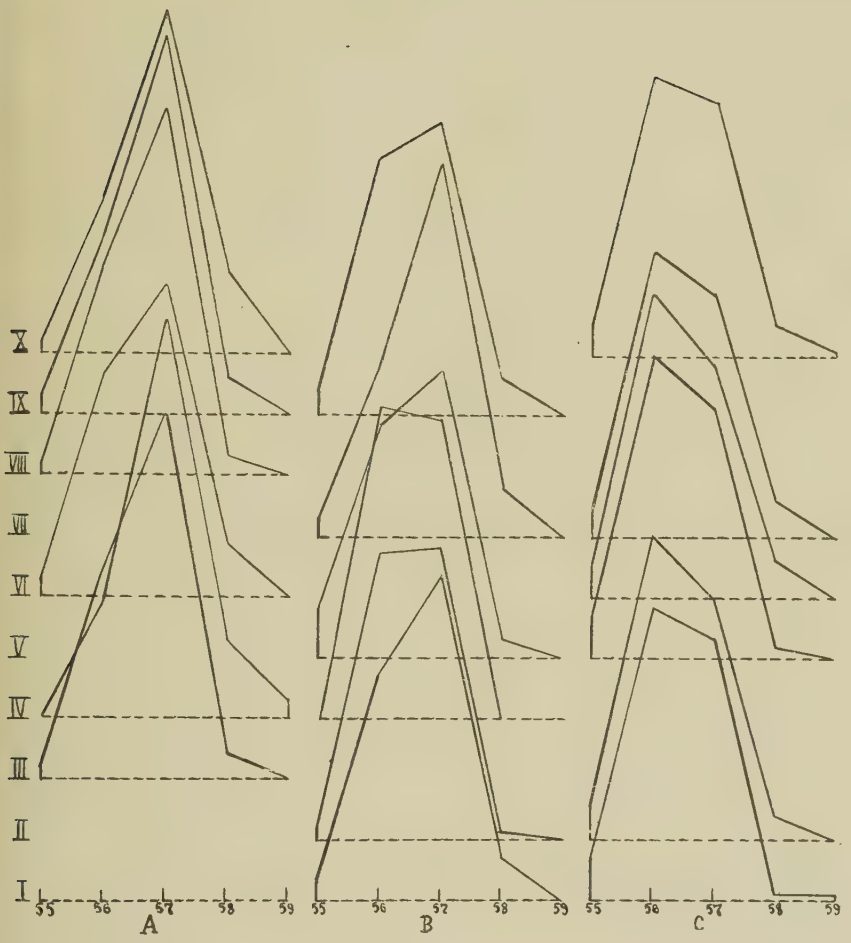

Abb. 3. Proz. Häufigkeitskurven des Merkmals Vert. S. von Proben aus dem Gebiet Fladengrund-Forties. Die Proben sind nach Reifezustand in drei Gruppen geteilt: *A* unreif (R. I u. II), *B* reifend (R. III u. IV), *C* reif (R. V.). Die oberste Kurve stammt aus einem Gebiet am weitesten nördlich (eben N von Fladengrund), die unterste aus einem Gebiet weiter südlich (Long Forties, querab Aberdeen).

Fig. 3. Percentage frequency curves of Vert. S. Samples from the Fladen ground to the Long Forties. The three groups are distinguished after the degree of sexual maturity: *A* contains unripe specimens (R. I and II), *B* filling (R. III + IV), *C* ripe (R. V). The arrangement of the curves is a geographical one; the uppermost concerns material from the northern Fladen ground, the undermost from waters off Aberdeen.

Kurven durchmischte Proben zeigen. Warum gerade die beiden Extreme die Kurvenbilder reiner Rassen darstellen, wird an anderer Stelle gezeigt.

Die Vorbedingung für diese Beweisführung ist aber eine genaue individuelle Reifebestimmung. Nach dieser muss dann eine Aussonderung der Proben erfolgen, damit für die verschiedenen Reifegruppen eine gesonderte Analyse erfolgen kann und eine Prüfung, ob die einzelnen nach Reife getrennten Bestandteile der Probe einheitlich sind. Die bisher übliche Methode der Reifebestimmung weist zwar gewisse Mängel auf, aber bei dem Fehlen anderer Anhaltspunkte muss man sich vorläufig mit diesem Ausleseverfahren begnügen.

Zur Beantwortung der Frage, ob von dem Vorhandensein wirklicher Rassen gesprochen werden kann, muss an Hand des vorhandenen Materials unter Berücksichtigung der hydrographischen Bedingungen geprüft werden, ob sich die Rassenmerkmale über einen grösseren Zeitraum hin und bei mehreren Jahresklassen konstant erhalten. Diese Prüfung kann an der Wirbelvariabilität beim Bankhering und Kanalhering (Abb. 2) vorgenommen werden, da hierfür hinreichendes Material vorliegt.

Bei beiden Formen zeigt sich nun über viele Jahre hin, beim Bankhering über 40 Jahre und zwischen einer ganzen Reihe von Jahresklassen, beim Kanalhering über 15 Jahre, eine durchaus gleich bleibende Wirbelvariabilität. Und das ist der Fall, obwohl einerseits auf die kritischen Entwicklungsstadien einer Rasse sehr verschiedene äussere Einflüsse einwirken, Temperaturunterschiede von mindestens 10°, Salzgehaltsunterschiede von mindestens $3^0/_{00}$, andererseits auf einzelne Individuengruppen von zwei Rassen ziemlich gleichartige äussere Einflüsse. Wenn das aber der Fall ist, wenn sich, wie hier gezeigt ist, ein bestimmter Charakter in der Wirbelvariabilität bei einer Rasse konstant erhält trotz starker Differenzen bei den Aussenfaktoren, zwei verschiedene Charaktere sich bei zwei Rassen konstant erhalten trotz gleicher Aussenfaktoren, so zwingt das zu der Schlussfolgerung, dass die Wirbelvariabilität bei einer Rasse unter den gegebenen normalen äusseren Einflüssen und unter den gegebenen normalen Schwankungen der Aussenfaktoren konstant und erblich ist.

Zum Nachweis der Rassen und zur Scheidung durchmischter Schwärme — und eine Durchmischung der Heringsschwärme ist fast überall in mehr oder weniger starkem Grade vorhanden — ist, wie erwähnt, eine individuelle Reifebestimmung Vorbedingung. Wie man dann zu einem Ergebnis kommt, mag ein Beispiel zeigen.

In der nordwestlichen Nordsee, Gebiet Fladengrund-Forties, findet

man die Reifestadien I—V in den sommerlichen Schwärmen. Die Sonderung muss in die Gruppen "unreif" (R. I u. II), "reifend" (R. III u. IV) und "reif" (R. V) erfolgen. Bestimmt man für diese drei Gruppen getrennt die Wirbelvariabilität, so kommt man zu folgendem Ergebnis (Abb. 3).

Sämtliche Gruppen mit Reife V zeigen einen ganz bestimmten, einheitlichen Charakter in der Wirbelvariabilität (Abb. 3 *C*). Demgegenüber zeigen die Gruppen der unreifen Heringe (Abb. 3 *A*) einen vollkommen anderen Charakter. Da die im Sommer dort gefangenen Heringe mit Reife V eben wegen ihres einheitlichen Reifezustandes einer einheitlichen, herbstlaichenden Fortpflanzungsgemeinschaft angehören müssen, und da alle Gruppen dieser Heringe eine einheitliche Wirbelvariabilität aufweisen, wird dadurch die Einheitlichkeit auch morphologisch bestätigt und diese Kurvenform als charakteristisch für die Rasse, die als Bankhering bekannt ist, festgestellt. Die Gruppen der reifenden Individuen (Abb. 3 *B*) erweisen sich vielfach als Durchmischungen aus den zwei Rassen, die durch die beiden extremen Kurvenformen (*A* und *C*) charakterisiert werden, nämlich vom Bankhering (*C*) und Hebridenhering (*A*). Die Variabiltätskurven der Wirbel zeigen beim Kanalhering und Hebridenhering zufällig eine gewisse Ähnlichkeit.

Durch Anwendung dieser Methodik konnte eine Reihe von Rassen bestimmt, Aufschluss über ihre Verbreitung und Wanderungen sowie über die Durchmischung der Schwärme in verschiedenen Gebieten gegeben werden. In der Nordsee ist die vorherrschende Rasse der Bankhering. Im Süden und besonders im Südwesten der Nordsee ist aber der Einfluss des Kanalherings, vor allen Dingen in vorgerückter Jahreszeit, von grosser Bedeutung. Westlich des Kanals schliesst sich als besondere Rasse der Hering der Smalls an, von dem der Klondyke-Hering im Norden von Irland zu unterscheiden ist. In der nordwestlichen Nordsee ist zunächst der frühjahrslaichende Firth of Forth-Hering zu erwähnen, der sich vom Bankhering deutlich unterscheidet, dessen Einfluss aber infolge des verhältnismässig geringen Individuenreichtums in der offenen Nordsee nur gering ist. Sehr wesentlich ist dagegen der Einfluss des Hebridenherings, der seine Hauptverbreitung in den Gewässern westlich der Shetlands und Nordschottlands hat.

In der südlichen Nordsee finden wir in den Küstengewässern und den vorgelagerten Meeresgebieten den wohlcharakterisierten Zuiderzee-Hering. In der östlichen Nordsee ist aber noch eine andere, herbstlaichende Rasse nachweisbar, die wahrscheinlich mit der bisher als Jütland-Hering bezeichneten Form identisch ist.

Bei dem bisher als einheitlich angesehenen Norwegischen Hering lassen sich zwei gut charakterisierte Rassen erkennen, deren Laichzeiten nur durch eine geringe Zeitspanne voneinander getrennt sein können.

Die Auffassung von dem Vorhandensein eines besonderen "Hochsee-herings der nördlichen Nordsee", eines "Doggerbankherings" und eines "Kanal-See-Herings" lässt sich nicht aufrecht erhalten.

Die ausgelaichten Bankheringe verstreuen sich über die gesamte Nordsee bis tief ins Skagerrak hinein. Sie lassen sich hier wie auf der Wiking Bank und in der südwestlichen Nordsee deutlich nachweisen.

Die Verbreitung der Jugendformen, ebenfalls bestimmt auf Grund der Wirbelvariabilität, steht in weitgehendem Zusammenhang mit den Strömungsverhältnissen. Damit stehen die Ergebnisse der Untersuchungen über das Vorkommen von Heringslarven in vollem Einklang. In der südlichen und südöstlichen Nordsee sind die Jugendformen vom Bankhering und Kanalhering in reinen oder durchmischten Schwärmen, teilweise auch vermischt mit dem Zuidersee-Hering, nachweisbar.

Résumé.

The importance and the success of racial investigations have been largely dependent on the constancy and hereditary fixation of those morphological characters which have been used for racial recognition and discrimination, and it is not surprising that these investigations have come rather to a stand-still, as in recent times the belief is increasing that the morphological characters are plastic and influenced in their development by prevailing external conditions, which of course involves a certain inconstancy of the characters.

Before we undertake such racial investigations anew, it is necessary to emphasise the fact that morphologically different groups may be considered as races only under the supposition that these morphological characters are constant and fixed by heredity. Characters that do not fulfil this supposition cannot be taken as true racial characters, and forms distinguished by them are not real races.

It is proved by many experiments, and cannot be denied, that external conditions are able to influence the development of the individual, the extent of this influence depending on the intensity of the stimulation and (on the other side) on the ability of reaction of the organism and its organs. The deviations established by experiment are mostly of a qualitative nature, concerning pigmentation, form, growth, covering of hair etc.,

whilst the characters used for the recognition of races in fishes are of a quantitative nature, as for instance the elements of the skeleton.

The development of the axial skeleton and of the fins in fishes is accomplished under conditions which allow little influence of external conditions; in the case of the vertebral column this effect is felt only in the very earliest period of development. In some fins, however, the developmental period may be long enough to allow these influences to operate, and the keeled scales especially may depend on the growth of the individual.

All cases in which inconstancy of characters has been thought to occur cannot stand serious criticism; they are often due to the intermingling of different forms which have not been recognised, or they have arisen from inequality in the sizes of the samples used for analysis.

A generalisation of the experiences obtained in experimenting with certain viviparous fishes is not admissible. The conditions prevailing in such cases and their dependence on the maternal organism are quite peculiar and allow no transmission to the common forms of fishes with pelagic eggs.

For the valuation of the different characters available and used for racial investigations of the herring the following statements may be made.

Though we have to depend on countable characters only, it can be shown that even these are of rather different value.

The ventral fins ought to be left aside, as the number of their rays is very much the same in all forms investigated, even when so far separated as Atlantic and Pacific herrings.

The dorsal and anal fins are of little value on account of their slight variability and the difficulty of counting the very first and incompletely developed rays in a comparable manner.

The counting of the keeled scales and the separation of the praehaemal and haemal vertebrae have to be accomplished with great care and exactness in order to avoid personal error, even if one and the same investigator is concerned.

The pectoral fins have proved to be a useful character; it is recommended that the total number of rays from both fins should be counted and that the small and unbranched filaments should be taken as full rays.

By far the most important character for racial investigations, as is generally acknowledged, is the total number of vertebrae. It is, however, not sufficient to calculate only the mean of the countings and the standard deviation, but it is necessary to draw the percentage fre-

quency curves, the form of which permits the recognition of the pure types as well as the degree of intermingling of different types.

A rather fundamental necessity in the racial investigations is the separation of the different stages of sexual maturity in the samples; therefore certain improvements in the determination of maturity are needed, and researches in the relative duration of the different stages are highly desirable.

The determination of l_1 on the scales has no obvious advantages for racial investigations.

The repeated study of the two most important herring races of the North Sea, the Bank-herring and the Channel-herring, reveals for both the fact of a constant variability of the number of vertebrae, though the populations of one race may grow up under quite different external (e. g. hydrographical) conditions, in the open North Sea or in coastal waters, — or populations of both different races may develop under the same conditions.

The spawning shoals afford the foremost clue for distinguishing races. The intermingling which as a rule occurs in the catchable shoals requires separation by stages of maturity before it is possible to decide on the denomination, taking into account the given seasonal and regional facts.

Beside the Bank-herring and the Channel-herring we have, in the North Sea, to deal with an autumn spawning Jutland herring and different spring-spawners, e. g. from the Firth of Forth and the Zuiderzee.

In the northern North Sea the influence of the west British herring from the Hebrides is very perceptible.

The Norwegian herring seem to belong to two different races, separated also in their spawning season.

A deep sea herring of the northern North Sea as well as a specific Dogger bank herring and a Channel sea-herring do not exist.

The distribution of the adolescent forms largely depends on the prevailing currents; and this fact makes it conceivable that the young of the Bank-herring and of the Channel-herring are found mixed up in the southern and southeastern North Sea.

Clupea harengus has to be considered as a combination of well characterised races (Rassenkreis), which may be compared to another similar combination called *Clupea pallasi* having a wide distribution in the Pacific. The existence of a phylogenetic connection between these two groups is very probable.

Bericht über Versuche mit dem schwedischen Schontrawl auf den Jungschollengründen der Deutschen Bucht.

Von

A. Bückmann, Helgoland.

Im Mai 1929 wurden vom "Poseidon" aus eine Reihe von Fangversuchen mit dem schwedischen Schontrawl angestellt, um die Eignung dieses Geräts zur Schonung untermassiger Schollen zu erproben. Dabei konnten die Erfahrungen benutzt werden, die von der Biologischen Anstalt seit 1927 bei Gelegenheit von Vorversuchen mit dem Schongerät auf dem Motorschiff „Augusta" gesammelt worden waren.

Für das Experiment des „Poseidon" wurde ein Fangplatz ausgewählt, auf dem gute Schollenfänge zu erwarten waren, und in dessen Nachbarschaft die Schollenfischerei von deutschen und dänischen Kuttern zu der Zeit wirklich ausgeübt wurde. An dem Fangplatz in der Durchfahrt der Amrum Bank war es möglich, die Lage des Zuges durch Kreuzpeilung (Amrum Bank Feuerschiff, Vortrapptief Tonne, Hörnum und bei Nacht Helgoland Leuchtturm und andere Landfeuer) genau festzulegen. Verwendet wurde die Originalform des schwedischen Schontrawls, mit zwei dicht aufeinanderliegenden Schonfenstern aus starren rechteckigen Maschen. Diese Form hatte sich auf der „Augusta" besser bewährt als einige gleichfalls erprobte Abänderungen. Das vom „Poseidon" benutzte Netz hatte 38 m Kopftau- und 45 m Grundtaulänge. Die Schonfenster massen $1{,}20 \times 2{,}00$ m und enthielten 14×70 Schonmaschen von $8{,}5 \times 2{,}5$ cm Weite. Die normalen Steertmaschen massen (in der Diagonale der langgezogenen Masche gemessen) 8 cm.

Um den Schoneffekt des Geräts zu ermitteln, sollten eine gleiche Zahl von Fängen mit dem Schontrawl und mit dem normalen Schleppnetz abwechselnd in ununterbrochener Folge gemacht werden. Die in beiden Geräten erzielten Gesamtfänge sollten dann verglichen werden.

Dies Verfahren zur Feststellung des Schoneffekts schien am geeignetsten, da das Prinzip des Hosentrawls aus technischen Gründen bei dem schwedischen Gerät nicht angewendet werden kann, und da die Verwendung des Fanges der Kontrollnetze über den Schonfenstern sich bei den Vorversuchen als irreführend erwiesen hatte. Benutzt man nämlich engmaschige Kontrollnetze, so halten diese auch solche Fische zurück, die durch die Maschen des normalen Steertes hätten entweichen können, sodass der Schoneffekt überschätzt wird. Nur während der ersten 4 Schontrawlfänge wurden Kontrollnetze über den Schonfenstern angebracht um festzustellen, ob nicht eine zu grosse Zahl von brauchbaren Schollen durch die Schonmaschen entkäme. Das war aber nicht der Fall, da die Kontrollnetze keine Schollen von mehr als 25 cm und nur einzelne Fische der Längen von 23—25 cm enthielten. Bei den Versuchen wurde immer dasselbe Vordernetz verwendet, nur der Steert wurde nach je 2 Fängen ausgetauscht, indem der Steert mit dem Schonapparat durch einen einfachen Steert ersetzt wurde oder umgekehrt.

Über die praktische Handhabung des Netzes ist zu sagen, dass das Aussetzen und Einholen der Kurre keine aussergewöhnlichen Schwierigkeiten bietet. Dagegen erwies sich die Konstruktion des Schonteils als zu schwach für die Beanspruchung, die das Gerät bei dem wiederholten Einziehen erfuhr. Die Maschen des Schonfensters werden bekanntlich durch einige quer über das Ober- und Unternetz gehende Stäbe ausgespannt gehalten. Das Tau, mit dem der Steert über Deck gehievt wird, wird oberhalb des Schonteils (nach der Netzöffnung zu) um das Netz gelegt. Es schnürt es zusammen, und besonders bei grösseren Fängen reisst infolge des entstehenden Zuges die Befestigung der Fenstermaschen am obersten Stabe, sodass die Maschen zur Mitte hin zusammenschnurren.

Es wurden mit jedem Gerät 10 Fänge gemacht. Für den Vergleich muss aber einer von diesen ausgeschieden werden, weil das Schiff unter dem Einfluss einer Gewitterböe erheblich vertrieben war und der Fang eine ganz abweichende Zusammensetzung zeigte. Weitere Schwierigkeiten ergaben sich aus der tageszeitlichen Veränderung der Fangmenge. Wenn auch im Laufe des Experiments mit beiden Geräten zu den verschiedensten Tageszeiten gefischt worden ist, so genügte der Umfang des Experiments doch nicht, um den genannten Einfluss ganz auszuschalten. Die tageszeitlichen Verschiedenheiten der Fangmenge waren grösser und setzten plötzlicher ein als erwartet worden war. Die folgende Tabelle gibt eine Übersicht über diese Verhältnisse:

Mittlere Fangmenge Stück:

Tageszeit		Scholle	Kliesche
Nacht. 20h—5h	Normales Netz	1402	343
	Schontrawl	1192	114
Tag. 8h—17h	Normales Netz	2555	542
	Schontrawl	2848	234
Dämmerung. 6h	Normales Netz	8008	1531
18h	Schontrawl	5457	608

Es wurden also in den Nachtstunden nur etwa halb soviel Fische gefangen wie am Tage, aber die Fänge in der Dämmerung waren noch ungleich grösser als die Tagfänge. Zwei dieser grossen Fänge sind mit dem normalen Trawl in der Morgenstunde gemacht worden, nur ein Fang mit dem Schontrawl am Abend.

Es ist am zweckmässigsten, diese drei Fänge bei der Ermittlung des Schoneffekts auszuschalten. Würde man sie mitrechnen, so wäre der Fang des normalen Trawls viel grösser als der des Schontrawls, und zwar gerade auch bei den grösseren Längen. Dies Ergebnis wäre aber zweifellos falsch. Betrachtet man nun aber die Fangmengen in den Tag- und den Nachtfängen, so zeigt sich, dass von Schollen in beiden Netzen ungefähr gleich viel gefangen sind, während das Schontrawl stets merklich weniger Klieschen gefangen hat. Das Ergebnis bezüglich der Scholle muss überraschen. Wenn eine nennenswerte Schonung ausgeübt worden wäre, so müsste der Durchschnittsfang im Schontrawl eine geringere Stückzahl aufweisen, als der in der normalen Kurre.

In der Tat zeigt eine genauere Prüfung des Materials, dass die Schonung ganz minimal, ja nahezu gleich 0 gewesen ist. Nach Ausscheiden der 4 oben bezeichneten Fänge verbleiben noch je 8 vergleichbare Fänge mit jedem der Geräte. In diesen 8 Fangstunden sind in jedem Netz ca. 16000 Schollen gefangen worden, deren Längenzusammensetzung in der folgenden Tabelle wiedergegeben ist. Bei einigen Längen sind im Schontrawl weniger Schollen gefangen als im normalen Trawl, sodass man von einer Schonung sprechen kann. Das ist der Fall bei den Längen von 5—8 cm und von 13—16 cm, allerdings nur in geringem Masse, wie der Schoneffekt zeigt, der in der Tabelle errechnet ist (in Prozent des Fanges in dem normalen Trawl). Doch findet sich solche Schonung auch bei den grösseren Schollen von 25 cm an, und von den dazwischenliegenden Längen hat umgekehrt das Schontrawl mehr gefangen als das nor-

male Trawl. Im ganzen genommen ist der Unterschied zwischen den beiden Messungsreihen nicht grösser, als er bei zwei Fangserien mit ein und demselben Gerät sein würde. Das beweist auch der geringe Unterschied in der Lage des Längenmittels beider Reihen: beim Schontrawl 20,60 cm, beim normalen Trawl 20,54 cm. Es ergibt sich also, dass praktisch garkeine Schonung erfolgt ist. Dies ungünstige Ergebnis ist übrigens nicht auf das Ausscheiden einiger Fänge aus dem Material zurückzuführen, denn auch bei den Gesamtmessungsreihen findet sich nur ein geringer Unterschied in der relativen Grössenzusammensetzung, und die Mittelwerte beider Reihen unterscheiden sich auch nur um den geringen Betrag von 0,3 cm.

Günstigere Ergebnisse dagegen haben wir bei der Kliesche. Schon an der oben angegebenen Durchschnittsfangmenge sahen wir, dass das Schontrawl stets viel weniger Klieschen fängt als das normale Netz. Aus den in der Tabelle gegebenen Messungsreihen der 8 Stunden-Fänge ersieht man, dass dies wirklich auf die Schonung der kleinen Klieschen zurückzuführen ist. Der Schoneffekt hält sich bis zu der Länge von 20 cm hin in sehr befriedigender Höhe.

Es ist sehr zu bedauern, dass diese Schonung nur die Kliesche, nicht die wirtschaftlich ungleich wertvollere Scholle betrifft. Aber gerade das Funktionieren der Schonung bei den Klieschen beweist, dass nicht unsachgemässe Anfertigung und Handhabung des Geräts Schuld an dem Versagen der Schonwirkung bei der Scholle haben, sondern vielmehr das Verhalten dieses Fisches im Netz und vor allen Dingen im Schonteil desselben. Auch bei den Vorversuchen war bereits festgestellt, dass der Schoneffekt bei der Kliesche bedeutend grösser war als bei der Scholle. Die Fische passieren, wie mehrfach beobachtet wurde, den Schonteil nicht einzeln während des Fanges. Da nämlich das obere und das untere Schonfenster dicht aufeinanderliegen müssen, so sammeln sich die Fische davor im Netzsack an und gleiten erst, wenn der Steert beim Hieven der Wasseroberfläche nahe kommt, in dichten Massen durch den Schonteil. Den breiteren und weniger beweglichen Schollen gelingt es dann anscheinend nur selten, durch die Schonmaschen zu entschlüpfen, während die schlanken und beweglichen Klieschen dies fertigbringen, wobei ihnen die Gewohnheit, den Körper stärker zu krümmen als die Scholle, zugute kommen mag. — Je mehr grosse Fische nun im Netz sind, umsomehr werden die Schonmaschen für die kleinen Schollen verdeckt werden; dadurch erklärt es sich wohl, dass wir bei den Vorversuchen mit der „Augusta", wo kleinere Fänge kleinerer Fische gemacht wurden, einen etwas günstigeren Schoneffekt beobachtet hatten.

Über das Funktionieren des Netzes bei Rundfischfängen kann nichts

mitgeteilt werden. Es hat sich jedoch bei den britischen Versuchen gezeigt, dass die Schonung z.B. kleiner Gadiden durch eine mässige Vergrösserung der Maschen des normalen Trawls zu erreichen ist. Kompliziertere Apparate werden erst dann nötig, wenn man kleine Plattfische schonen will, ohne wesentliche Mengen von brauchbaren Rundfischen zu verlieren. Von den zu schonenden Plattfischen ist aber die Scholle unzweifelhaft die wichtigste. Die untermassigen Seezungen entkommen auch durch die Maschen des gewöhnlichen Fischdampfertrawls, die Klieschen sind in der Nordsee wirtschaftlich ziemlich bedeutungslos und bei den anderen Arten ist über die Vernichtung von Jungfischen kaum je Klage geführt worden. Wenn daher der Schoneffekt des Geräts in Bezug auf die Scholle fast alles zu wünschen übrig lässt, so ist das ein sehr ernst zu nehmender Mangel. Dazu kommt der Umstand, dass die Schonapparatur, wie oben erwähnt, leicht verletzlich ist. Häufige Reparaturen aber werden im praktischen Gebrauch als sehr lästig empfunden werden.

Schoneffekt des Schwedischen Schontrawls gegenüber dem normalen grossen Trawl des „Poseidon" Mai 1929.

I. *Scholle.*

Länge cm	Normales Trawl Anzahl	Schontrawl Anzahl	Schonung Anzahl	Schoneffekt %	Mehr im Schontrawl Anzahl
5—6	26	4	22	85	..
7—8	65	32	33	51	..
9—10	58	60	..	..	2
11—12	489	500	..	..	11
13—14	1427	1161	266	19	..
15—16	1204	1124	80	7	..
17—18	1937	1991	..	..	54
19—20	2756	3100	..	..	344
21—22	3283	3790	..	..	507
23—24	2434	2604	..	..	170
25—26	1287	1207	80	6	..
27—28	613	409	204	33	..
29—30	197	137	60	30	..
31—32	44	38	6	14	..
33—34	6	4	2	33	..
35—36	2	0	2	100	..
37—38	2	1	1	50	..

II. *Kliesche.*

Länge cm	Normales Trawl Anzahl	Schontrawl Anzahl	Schonung Anzahl	Schoneffekt %	Mehr im Schontrawl Anzahl
3—4	4	0	4	100	..
5—6	34	3	31	91	..
7—8	12	4	8	67	..
9—10	239	51	188	79	..
11—12	599	185	414	69	..
13—14	644	210	434	67	..
15—16	801	265	536	67	..
17—18	603	249	354	57	..
19—20	265	142	123	46	..
21—22	157	98	59	38	..
23—24	111	94	15	14	..
25—26	45	61	..	..	16
27—28	21	26	..	..	5
29—30	4	2	2	50	..
31—32	2	1	1	50	..

Some Remarks on the Graduation of Measurement Data.

By

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This paper deals particularly with some methods of treating ichthyometric data. The methods are, however, applicable to many other cases of frequency distributions. They have special reference to the graduation of length-measurements of fish made by means of a pin on celluloid slips[1]), in which case the measurements are originally ungraduated and may be graduated subsequently in any way desired. The methods are, however, applicable in modified form to the case of measurements made originally in class-intervals, for instance centimetre intervals.

To avoid too theoretical a discussion it is proposed to explain the treatment of the data entirely by means of examples. The first examples given are taken from measurements of plaice made on celluloid slips. The fish were taken in an inshore trawl in early August (Aug. 1st—8th) 1928 on the inshore grounds near Beer in Devonshire. The plaice taken on each day were measured on one slip, with the exception of those taken in a few hauls which were for some reason or another not comparable with the remainder. Fig. (1 *a*) shows the distribution of the pin-pricks on the slip for $^3/_8$ 28. On all slips a line was drawn at 15 cms. from the block against which the noses of the fish were pressed. The frequency distribution of the pin-pricks is not easy to grasp when they are dispersed widely on the slips and therefore the pin-pricks were projected with a parallel ruler near to a line at right angles to the 15 cms. line by which each slip was orientated. Fig. 1 (*b*) to (*h*) shows the distri-

[1]) Journ. du Conseil, Vol. III, No. 3, p. 380.

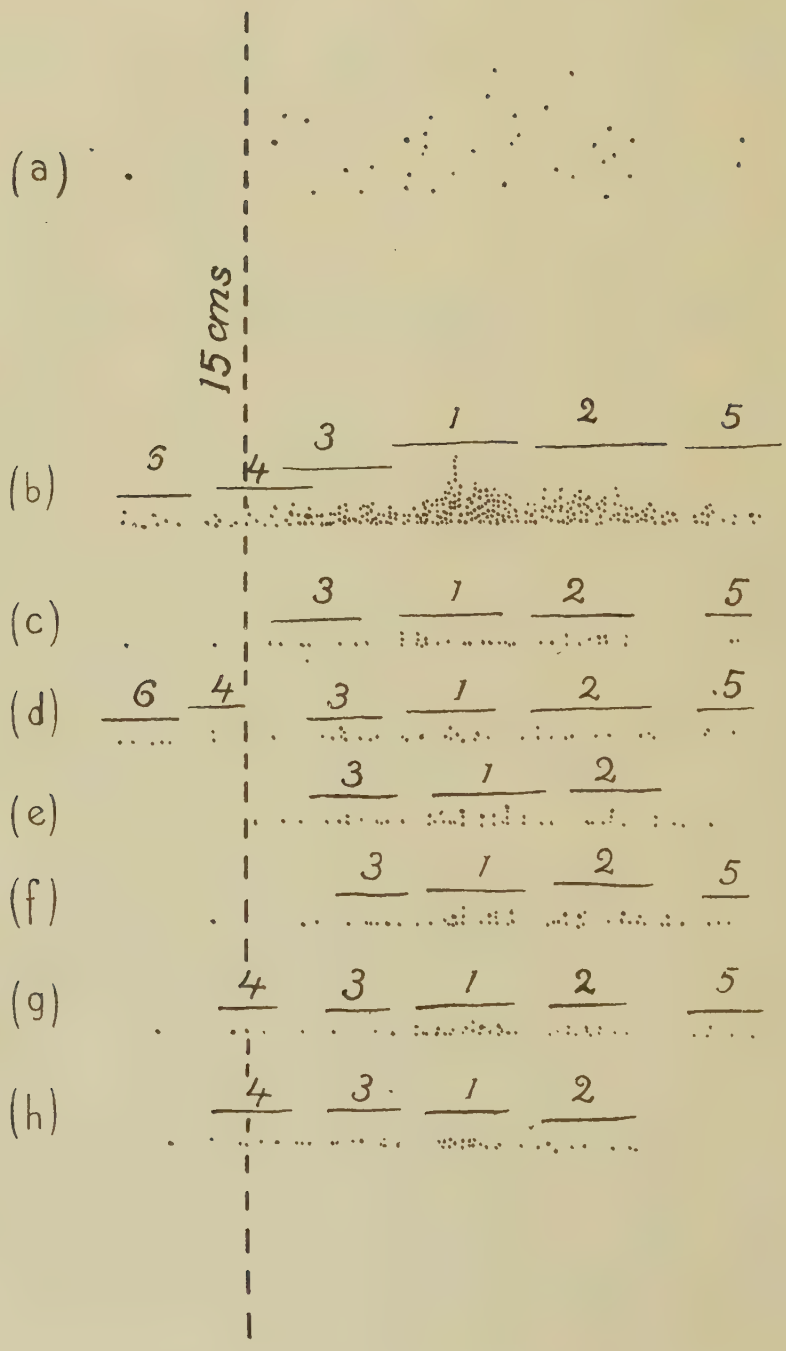


Fig. 1.

bution of pin-pricks after this projecting process, (*c*) to (*h*) giving the distribution for each day separately, (*b*) giving the total.

Before proceeding, it should be mentioned that only the measurements of the I-group[1]) are shown on these slips, those of the older fish being omitted. On a glance at Fig. 1 it is at once obvious that the measurements fall into subgroups, and cannot by any stretch of imagination be regarded as conforming to a simplex frequency distribution. The subgroups, which have been numbered 1 to 6 according to their number content, are indicated by horizontal lines. It is not, of course, possible to find the exact centre or the exact range of each subgroup, but the fact that a connecting line, varying only $^1/_4$ cm. from straightness can be drawn through the apparent centres of corresponding subgroups in each day's data seems sufficient proof of their reality[2]). Some of the subgroups seem to be again divisible into subgroups of a lower order, but there would appear to be no advantage to be gained by carrying analysis further than the main subgroups. It is necessary, however, to have regard for the main subgroups, for the following reasons. A subgroup is of such narrow spread that its position is given accurately enough even if it is represented by only a very few fish. Thus the positions of corresponding subgroups may be compared in different samples though all the subgroups may not be represented in each sample and may appear in quite different proportions in different samples. Consistency in position is the test of correspondence between subgroups. It has been suggested that the appearance of subgroups is due to errors of random sampling, but when there is consistency in their positions this cannot be the case. Errors due to random sampling certainly may account for the fact that the subgroups do not conform very nearly to a smooth frequency curve and may account in part for variations in their apparent representation. The main object of fitting a frequency curve to a group of measurements or drawing a smooth curve near the points corresponding to rough data is to smooth out irregularities due to random sampling. The curve is held to give a result more nearly in correspondence with that which would be obtained if the whole "sampled universe" were measured than that obtained from the rough points themselves. Given that the curve is well chosen and that the roughnesses of the data are really due to random sampling, this belief is in general justified by results. It is necessary, however, so to

[1]) As shown by otolith readings.

[2]) For a practical method for resolving such complex frequency distributions into their component sub-groups, see Wollaston & Hodgson, Journ. du Conseil, Vol. IV, No. 2, p. 207 *et seq.*

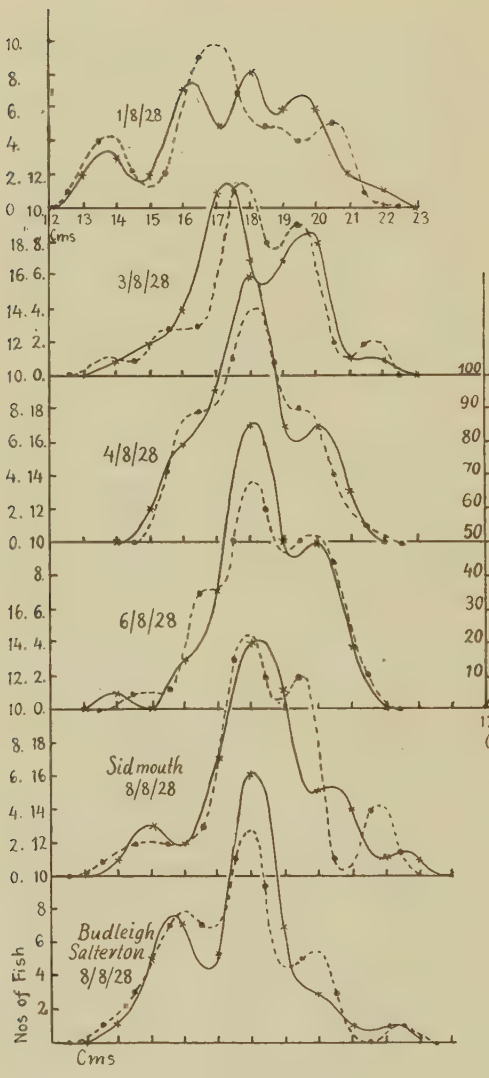


Fig. 2.

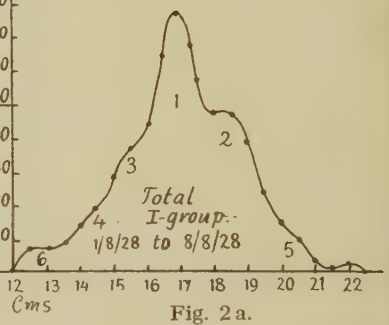


Fig. 2a.

group the original measurements and to choose such a method of drawing a curve that consistent irregularities are not obscured.

If we have continuous and ungraduated original data as given on celluloid measuring slips we can graduate them in any desired manner. We may put them into half-centimetre, centimetre or other equal class-intervals or we may use *variable* intervals on the axis of abscissae. The curves in *continuous* line in Fig. 2 are drawn in as smooth a manner as possible through the points representing the data shown in Fig. 1 after grouping at each centimetre, that is to say all measurements between

14.5 and 15.5 cms. are grouped together and so on. We may change the limits of grouping, taking 15.5, 16.5 and so on as the centres. The resulting curves are shown in broken line in Fig. 2; the two sets of curves are fairly consistent on the whole as to the positions of the chief modes, though the proportionate representation of some of the subgroups is not in agreement in the two sets. The subgroups 1, 2, 3, 4 and 5 would be placed in the same order of magnitude whether we had one set of groupings or the other, and this is sufficient proof of their reality. The dots and crosses are really points on the same curve, but if we draw this curve we shall find that we begin to reproduce inconsistent irregularities in the data. Overlapping grouping carried to the limit will reproduce all the irregularities of the original data and this does not seem desirable unless large samples are being dealt with, in which case irregularities due to random sampling may be expected to disappear. Fig. 2*a* shows the curve for all the measurements shown in Fig. 1 (*c* to *h*). There are sufficient data here for the method of overlapping to be used, the points on the curve corresponding to the number of pin-pricks in centimetre intervals which overlap the adjacent intervals to the extent of half a centimetre. Since the original data are continuous, this is a true interpolation method and is not at all analogous to methods of smoothing which, in data of measurements originally grouped in centimetres, combine the data of several centimetre intervals into larger intervals overlapping each other. These latter methods are quite artificial, while the former is merely a means of using additional information inherent in the data themselves. It is useless to attempt interpolation by overlapping centimetre intervals in cases where the original data are grouped in centimetre intervals. The intermediate points on the resulting "curve" would of course lie on straight lines between the original points and not on a continuous curve at all. Fig. 2 (*a*) shows well the great advantage of having originally ungrouped data. It also indicates that, in cases where the data are originally grouped in cms., drawing a continuous curve through the centimetre points on the assumption that the group is complex and made up of subgroups fairly nearly symmetrical and of narrow range is likely to give a result far nearer the truth than either smoothing out the original "roughnesses" by drawing a continuous simplex curve near the points or joining them simply by straight lines. The last method is, of course, known to be wrong in every case. It often hides statistical facts, instead of showing them clearly which is supposed to be the main function of diagrams. It is undoubtedly one of the worst possible ways of graphing data and

it is difficult to comprehend why it should be so persistently used in fishery research.

Before proceeding to discuss the question of grouping data in variable intervals, it is advisable to consider generally the question of growth and growth-rate. Assuming that a number of plaice-eggs are hatched simultaneously, the resulting fish, growing up under natural conditions, will not all have the same length after a year, but these lengths will form a frequency-curve. The curve will be unimodal if there are a large number of variable subjective and objective conditions which influence growth, but of which the variation is continuous and such that the fish may all be said to have lived "under the same conditions" during the period. To attempt to define more precisely this somewhat vague phrase might introduce mere mathematical abstractions without a counterpart in Nature. Growth of a group of fish during the first year is thus what we may term divergent. The lengths of the larvae on hatching would spread over only two or three millimetres at most. The lengths of the same fish after a year's growth would undoubtedly spread over at least two centimetres. Thus to obtain a frequency-curve for larvae we should have to group the measurements in millimetres or half-millimetres; to obtain a corresponding curve for the year-old fish, grouping would have to be in centimetres or half-centimetres. We may now make another definition, namely that of "parallel growth" of a group of fish. In "parallel growth" the result at the end of the period is the same as if every fish had grown the same amount in the given period, thus, in our hypothetical group, the measurements at the end of a year would still have to be grouped in millimetres or half-millimetres to form a frequency-curve. The third type of growth is the convergent or compensatory type. In this type, at the end of any period the group has less "spread" than at the beginning of the period. We are not referring at the moment to growth-type pertaining to a particular fish. In that case divergent growth may be defined as growth persistently greater or persistently less than the average. It is quite clear that, though every fish in a group may indulge, during any subperiod, in any one of the three types of growth, the growth of the group as a whole must be divergent. Anything else would be absurd in the period of free growth, before the onset of maturity introduces a point of discontinuity. It is impossible of course to trace the growth of an individual fish under natural conditions by observations on the fish itself. We may, however, trace the life-history of a plaice by calculation from the otolith, by a method corresponding to that used in calculating the growth of a herring from its scales. This use of otoliths has been tested in the case of about 50 fish which were

marked in late summer and autumn in the Poole district of Dorset and the Beer district of Devon and which were recaptured at various times in the year after marking. At the time of year at which the fish were marked the edges of otoliths show, nearly always, dark growth. In every case the calculated position of the edge of the otolith on marking proved to be in the "dark growth" of the preceding year or just on the edge of the white growth, thus, exactly where one would expect it to have been in reality. This method of course does not assume that the size of

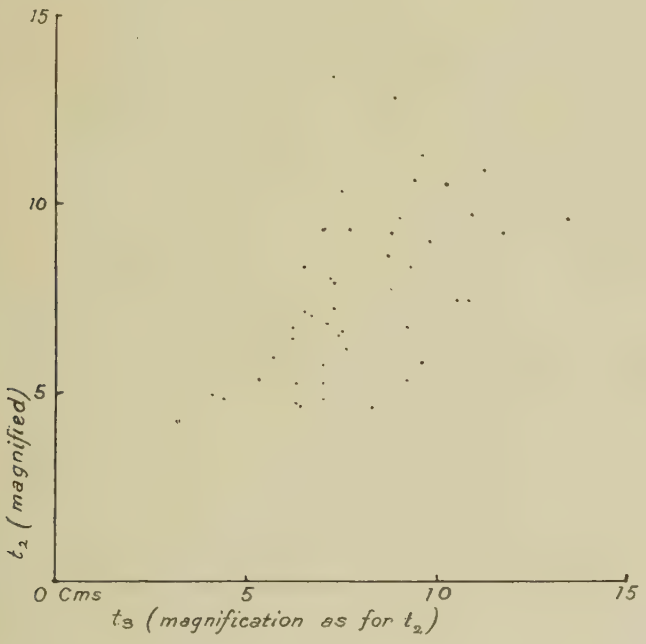


Fig. 3.

an otolith is proportional to that of the fish to which it belongs. This proportion varies quite widely owing to differences in shape of otoliths. The method assumes only that in each fish the otolith grows, in length as measured from the nucleus, proportionally to the fish. The average length of the otoliths has been found to be approximately a linear function of that of the fish, in spite of the variation in shape. It thus appears to be quite safe to assume that in most cases the otolith gives a picture of the past growth of a plaice, the picture being probably as reliable as that given by scale readings in the case of the herring. As compared to such scale-calculations, otolith calculations show the advantage that their reliability may, in any district, be tested on fish marked in autumn or winter. This question will be dealt with much more fully in a sub-

sequent paper. It is introduced here merely because it provides a means for testing whether growth, in a given sample of fish, has been divergent, in the sense that growth in the individual fish has been on the whole divergent.

Calling the length-increment in the first year of life t_1, that in the second year t_2 and so on, as in the corresponding herring-scale work, we may compare these increments and examine whether a large "t" in one year is correlated with a large "t" in another year or the reverse. Thus we may find out whether the growth in the years dealt with has been divergent, parallel or convergent. It is of little use attempting to correlate t_1 with a subsequent increment, since the value of t_1 depends so very much on the time at which the corresponding fish was spawned. The spawning-season extends over four months, and this spread is quite sufficient to give a very wide "range" to t_1. Correlation between t_2 and t_3 should, however, give a useful picture. If positive, growth in the 3rd and 4th years of the life of the fish is divergent, if absent, growth is parallel, if negative, growth is convergent. Fig. (3) shows the correlation between t_2 and t_3 in the case of all the otoliths which were preserved after being taken from fish of 3 years old and upwards during the years 1924 to 1927 in the Poole district. Selection of these otoliths for preservation was quite haphazard since the idea of using them for growth calculations only arose last year (1929).

Fig. (3) shows that correlation between t_2 and t_3 is in this case quite definitely positive, and therefore that individual growth is divergent in general. Fig. (4) shows l_1, l_2, and l_3 for the same collection of plaice[1]). In this figure m represents the median, q_1 and q_2 the quartiles. In Fig. (5) the total range and the interquartile range of l_1, l_2 and l_3 are given compared to the median lengths. It will be seen that the interquartile range is proportional to the median length. The total range in l_3 may well be affected by the onset of maturity in the fourth year in the case of fish with an abnormally large l_2. Therefore the variation of the interquartile range is probably a more reliable index of increasing spread of a group than the total range of l_1 and l_2.

In cases such as the above, *the sizes of the class-intervals should be proportional to the size of the variates.* If a one-centimetre interval is used for fish of 15 cms., a 2-cm. interval should be used for those of 30 cms., a half-centimetre interval for fish of 7 to 8 cms. and so on. If this is not done, it cannot be expected that only modes or subgroups of the same order will be shown in curves of different year

[1]) l_1, l_2, l_3 = calculated length of fish at first appearance of 1st, 2nd and 3rd white ring on otolith.

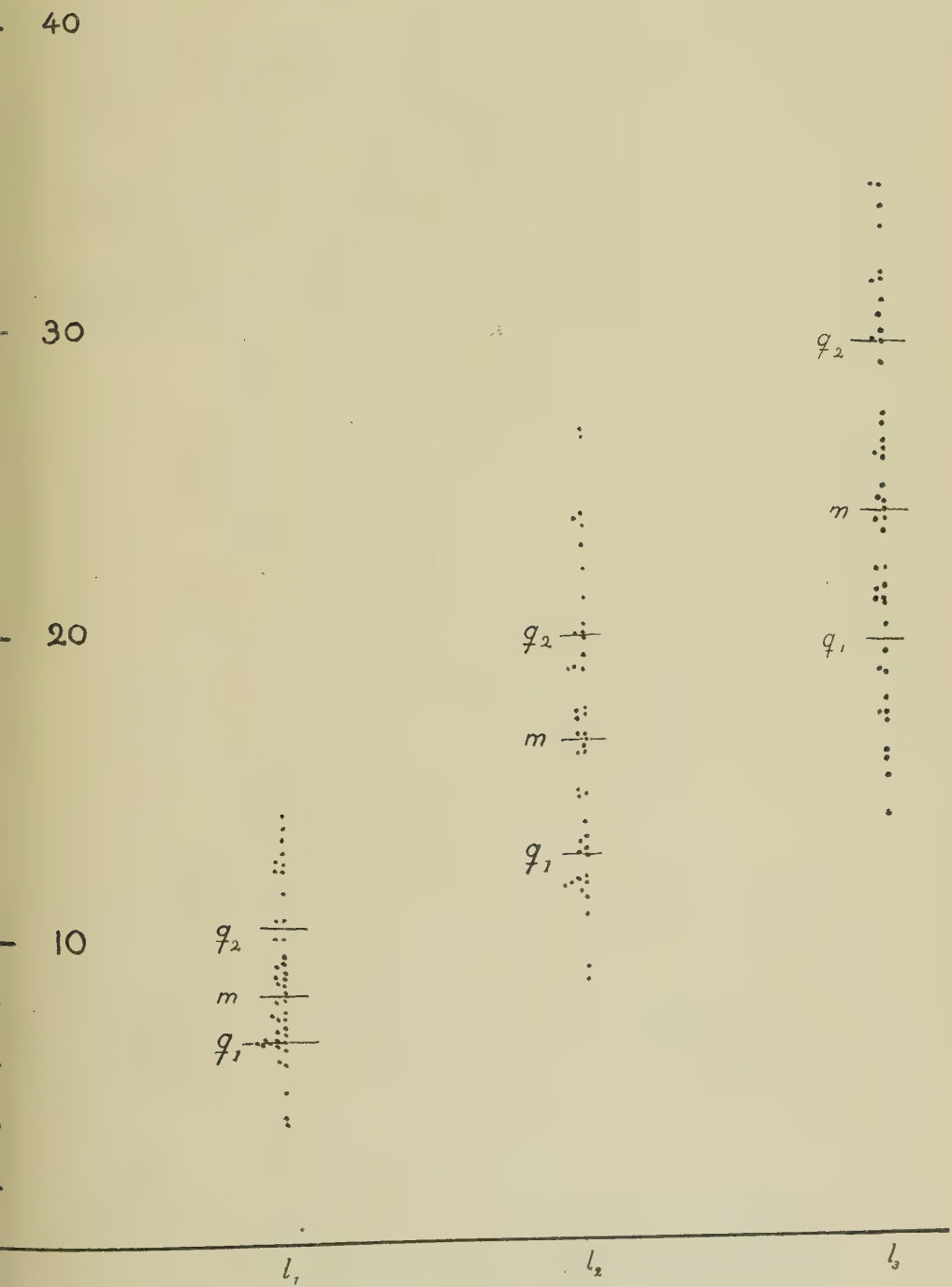


Fig. 4.

classes to be compared. If the modes in the I-group are considered significant for comparison, there will be too few modes in the 0-group, too many in the II-group, and any law there may be connecting the modes in the groups will be obscured.

Table (1) gives the end-points and midpoints of class-interval scalculated on the hypothesis that a 1-cm. interval is correct for fish of 15 cms. the other class intervals being proportional to the length of the variates. The ordinates below the 15-cm. point are smaller than those for equal class-intervals, and above that point are larger. Therefore, if

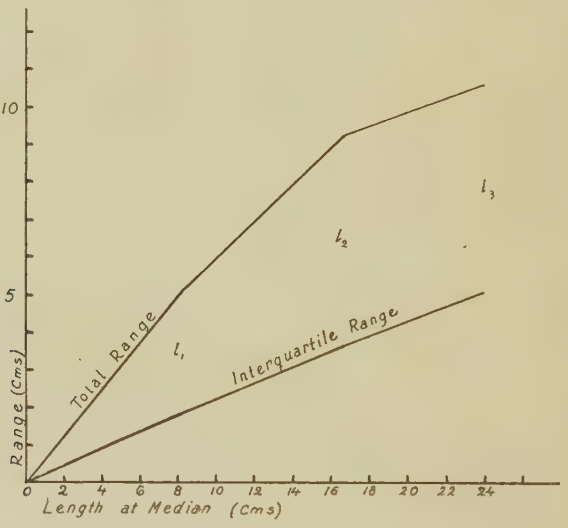
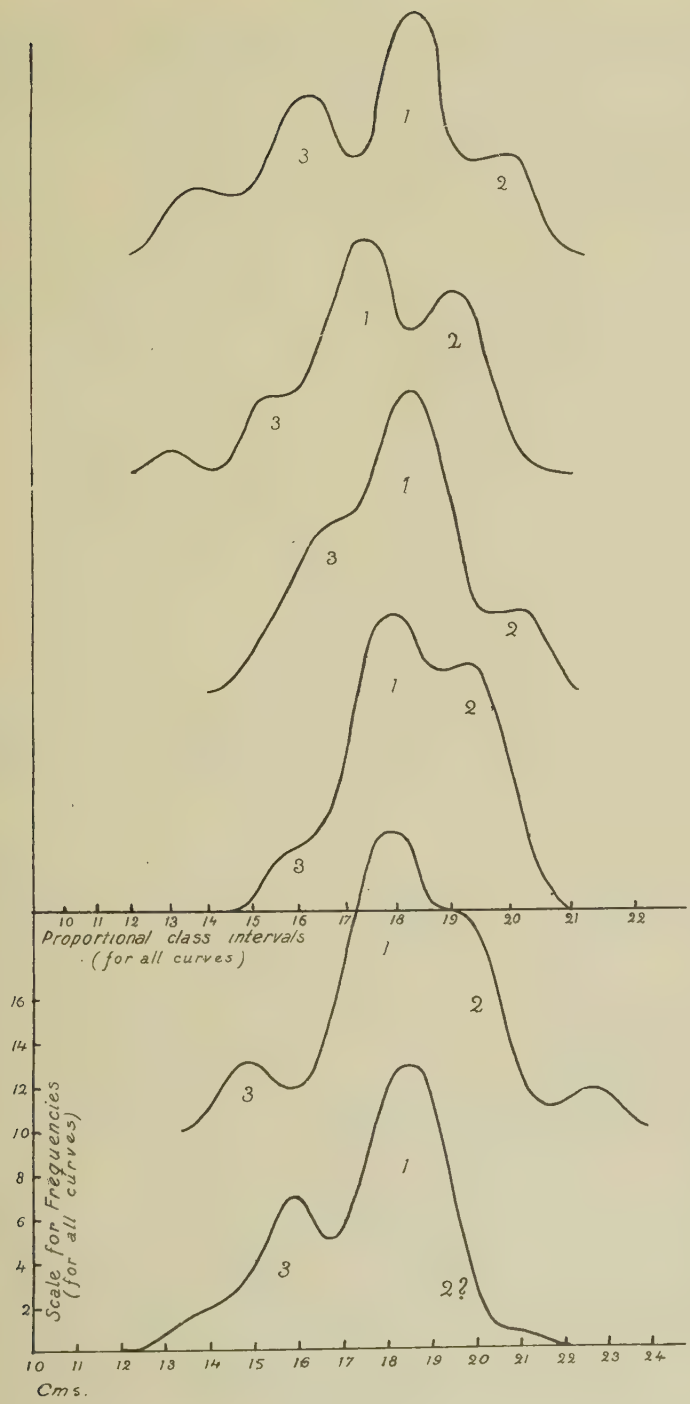


Fig. 5.

it is desired to compare a curve drawn from proportionally grouped data with a curve drawn from equally-grouped data, each class-frequency in the former must be multiplied by the reciprocal of the length of the class interval measured in centimetres. If this is not done the two curves will have different areas. The reciprocals are given in Table (1). The end points are calculated as follows. The end-points of the class-interval 15 are 14.5 and 15.5. Thus any end-point, say "$n + 1$" is given by multiplying the end-point "n" by $\frac{15.5}{14.5}$ or 1.069. Any end-point "$n - 1$" is obtained by multiplying "n" by $\frac{14.5}{15.5}$ or .9354[1]). If the original data

[1]) The continuous use of a decimal to four places only gives rise to an error which becomes serious in the upper intervals. Table 1 was calculated, with a mechanical calculating-machine, using the greatest number possible of significant figures.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3
1
2
3
1
2
3
10 11 12 13 14 15 16 17 18 19 20 21 22
Proportional class intervals
(for all curves)
1
2
3
1
3
2?
Scale for Frequencies
(for all curves)
2 4 6 8 10 12 14 16
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Cms.

Fig. 6.

are ungrouped we may use the overlapping method of grouping, as was done in the case of centimetre-grouping, by taking, as intermediate ordinates, the data falling between adjacent mid-points in the proportional series. By continued overlapping, every character of the original collection of data will be reproduced in the curves.

Fig. (6) shows curves drawn from the data given in Fig. 1, grouped

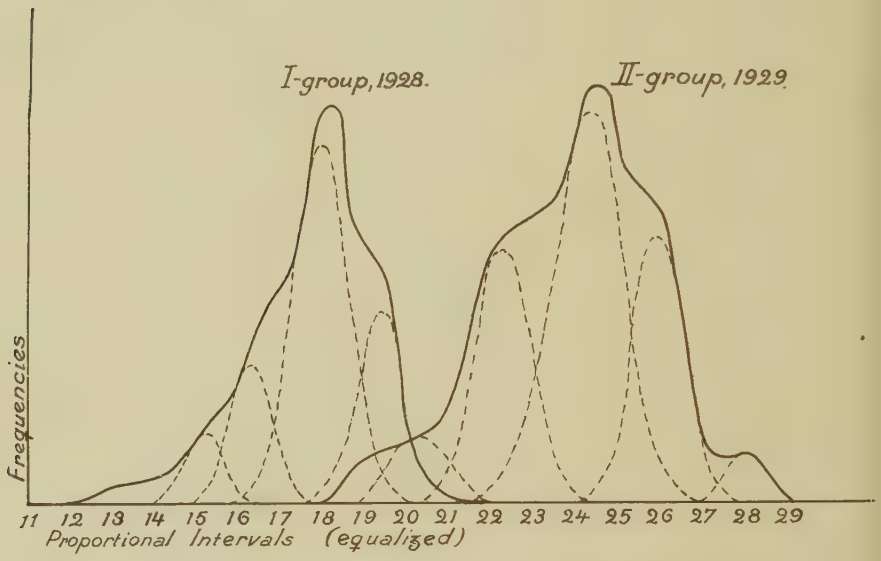


Fig. 7.

in proportional intervals. The positions and relative richness of the subgroups 1, 2, and 3 are well shown in the curves, but the smaller subgroups 4, 5, and 6 are apt to become included in the ends of the larger groups. Whether this matters or not depends on the purpose for which the curves are drawn. If this purpose is the comparison of the n year old fish of one year with the $(n + 1)$ year old fish of the next year with the object of deducing growth between the two years, it is probably sufficient to limit ourselves to the richer subgroups and to neglect the "tail-groups". These in any case form but a very small proportion of the whole collection.

In comparing the I-group with the II-group, using proportional class-intervals, it is assumed, *ipso facto*, that the range of each group is proportional to the size of the variates. If that assumption is correct, for the purpose of comparison the class-intervals should be regarded all as equal, and the ordinates should not be multiplied by the reciprocals. Fig. (7) shows such a curve for all the fish of the I-group measured in the

Beer district in August 1928, compared with that for all the fish of the II-group measured there in August 1929. There were not nearly so many fish of the II-group as of the I-group, therefore the curves have been drawn on different scales, chosen so as to make the highest ordinate of each curve about equal. In drawing the I-group curve we may be guided by our knowledge of the component subgroups obtained from examination of the original data or of the "overlapping centimetre" curve Fig. (2*a*). The II-group curve cannot reasonably be drawn except as shown, having regard to the fact that all frequency-groups so far examined, pertaining to a year-class of plaice from either the Poole or the Beer district, resolve into component subgroups approximately symmetrical and of narrow range. It will be seen then that the subgroups of the I-group 1928 are all represented in the II-group 1929, and their comparative representation, their order of importance, is the same in the two curves. The spread of the II-group curve is, however, still greater than that of the I-group curve. If the same population is being sampled in both cases, we are forced to the conclusion that the increase of spread with size is even greater than directly proportional. It may be, however, that the net did not take all the fish on the lower side of the I-group in 1928. When they enter the II-group these fish will of course be properly sampled. This method gives what would appear to be a reliable method of growth-determination. The main mode in the I-group is at 18.3 divisions (= 18.645 cms.), and that in the II-group at 24.6 divisions (= 28.344 cms.) the growth between August 1928 and August 1929 is thus 9.7 cms. This method of estimating growth assumes, of course, that the same population is being dealt with in both cases, but the similarity in shape of the two curves appears to indicate that at least the main mode in one curve corresponds to that of the other. The modes are much better suited for growth-rate calculations than are the means. The central mode would be very little changed as to position by the addition of a large number of fish of subgroup 3, while the mean would be much reduced by the same addition. If it is required to deduce the growth rate of the whole of the I—II-group represented by the samples, the curves may be resolved into components as shown in broken line in Fig. (7). This diagram is only intended as an indication of the way in which the problem may be attacked. Strictly speaking, if these component curves are symmetrical when the variates are grouped in equal class intervals, they should be positively skew[1]) when the variates are grouped in proportional intervals "equalized". To resolve the whole, however, into the most

[1]) If the mean is greater than the mode, skewness is termed positive and *vice versâ*.

probable skew components is an elusive problem at best. It may be preferable to carry out the resolution on curves drawn on the original "unequalized" proportional intervals, and to assume that they are symmetrical in the absence of other indications. It should be mentioned, though, that in cases where the individual variates themselves show proportionally divergent growth, positive skewness in the frequency curve is produced. It is quite possible that such positive skewness is what may be expected in frequency-curves of fish measurements. The solution of such a problem, however, requires much wider research than has been undertaken up to the present time. In a case such as the present,

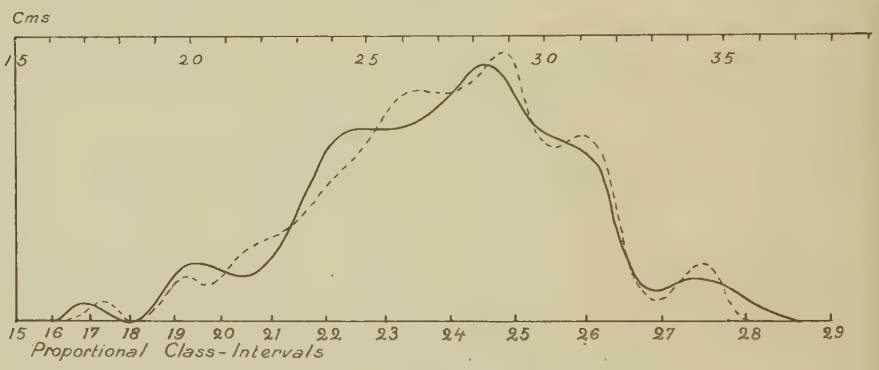


Fig. 8.

the subgroups are of such small range that failure to assign the correct skewness would have little effect on the indicated positions of the modes. These are all we require for growth-calculations on the basis of comparison of frequency-curves.

In such growth-calculations it is usually necessary to use proportional class-intervals for the reasons already stated. This is illustrated in Fig. (8). This figure shows, in unbroken line, the II-group of 1929, in proportional class-intervals unequalized, the ordinates being multiplied by the corresponding reciprocals; the broken line is the frequency-curve for the same data in centimetre class-intervals. The latter curve shows four closely placed modes on the left-hand side.

The majority of fish measurement data are originally grouped in equal class-intervals. The rigid method of proportional grouping cannot be used with such data, but it may be modified to meet such cases. We may assume that each frequency is equally distributed throughout its class-interval. This is straining Nature no more, indeed much less, than the usual assumption that it is concentrated at the centre of the class-interval. We may now allot the appropriate proportions of each frequency

Table 1. Proportionate Intervals (15 = 15 cms.).
End-points, Centre-points, Reciprocals of Lengths.

Interval	Ranges Cms.	Reciprocal of Length of Interval in cms.	Midpoint Cms.
0	5.33— 5.70	2.70270	5.52
1	5.70— 6.09	2.56410	5.90
2	6.09— 6.51	2.38095	6.30
3	6.51— 6.96	2.22222	6.74
4	6.96— 7.44	2.08333	7.20
5	7.44— 7.96	1.92308	7.70
6	7.96— 8.50	1.85185	8.23
7	8.50— 9.09	1.69492	8.80
8	9.09— 9.72	1.58730	9.41
9	9.72— 10.39	1.49254	10.06
10	10.39— 11.10	1.40845	10.75
11	11.10— 11.87	1.29870	11.49
12	11.87— 12.69	1.21951	12.28
13	12.69— 13.56	1.14943	13.13
14	13.56— 14.50	1.06383	14.03
15	14.50— 15.50	1.00000	15.00
16	15.50— 16.57	0.93458	16.04
17	16.57— 17.71	0.87719	17.14
18	17.71— 18.93	0.81967	18.32
19	18.93— 20.24	0.76336	19.59
20	20.24— 21.63	0.71942	20.94
21	21.63— 23.13	0.66667	22.38
22	23.13— 24.72	0.62893	23.93
23	24.72— 26.43	0.58480	25.58
24	26.43— 28.25	0.54945	27.34
25	28.25— 30.20	0.51282	29.23
26	30.20— 32.28	0.48077	31.24
27	32.28— 34.51	0.44843	33.40
28	34.51— 36.89	0.42017	35.70
29	36.89— 39.43	0.39370	38.16
30	39.43— 42.15	0.36765	40.79
31	42.15— 45.06	0.34364	43.61
32	45.06— 48.16	0.32258	46.61
33	48.16— 51.48	0.30120	49.82
34	51.48— 55.04	0.28090	53.26
35	55.04— 58.83	0.26385	56.94
36	58.83— 62.89	0.24631	60.86
37	62.89— 67.23	0.23041	65.06
38	67.23— 71.86	0.21598	69.55
39	71.86— 76.82	0.20161	74.34
40	76.82— 82.12	0.18870	79.47
41	82.12— 87.78	0.17668	84.95
42	87.78— 93.83	0.16529	90.81
43	93.83—100.30	0.15456	97.07
44	100.30—107.22	0.14451	103.76
45	107.22—114.62	0.13514	110.92

Table 2. Length-Measurements of Plaice of the II-group 1929, originally in cm. groups, showing Allotment to Proportional Intervals.

Cms.	No.	Prop. Ints.	Proportions of cm. inst.	No to nearest .5	Nos. of originally ungrouped data
18	0	18	$.39 \times 17 + .93 \times 18$	0	0
19	2	19	$.07 \times 18 + 19 + .24 \times 20$	2 + .5 = 2.5	3
20	2	20	$.76 \times 20 + .63 \times 21$	1.5 + 2.5 = 4.0	4
21	4	21	$.27 \times 21 + 22 + .13 \times 23$	1 + 5 + 1 = 7.0	6
22	5	22	$.77 \times 23 + .72 \times 24$	5.5 + 6.5 = 12.0	15
23	7	23	$.28 \times 24 + 25 + .43 \times 26$	2.5 + 12 + 5.5 = 20.0	18
24	9	24	$.57 \times 26 + 27 + .25 \times 28$	7.5 + 13 + 4 = 24.5	23
25	12	25	$.75 \times 28 + 29 + .20 \times 30$	11 + 11 + 2 = 24.0	24
26	13	26	$.8 \times 30 + 31 + .28 \times 32$	8 + 9 + .5 = 17.5	19
27	13	27	$.72 \times 32 + 33 + .51 \times 34$	1.5 + 2 + 1.5 = 5.0	4
28	15	28	$.49 \times 34 + 35 + .89 \times 36$	1.5 + 0 + 0 = 1.5	3
29	11	29		0	0
30	10			118	119
31	9				
32	2				
33	2				
34	3				
35	0				
36	119				

to the corresponding proportional class-interval. Thus the proportional interval "15" contains half the frequency of the 14 cm. class-interval, half that of the 15 cm. class-interval, the proportional interval 29 contains .11 of the frequency of the 36 cm. class-interval plus the whole frequencies of 37 and 38 cms. + .43 of the 39 cm. interval.

The result cannot be expected to be so near to reality as that obtained from ungrouped original data. By its use, however, we do obtain the benefit of allowance of increasing spread of a group with increase in size of the variates.

It will be interesting to test this modified method on the figures illustrated by Fig. (8). Table (2) shows the working, and compares the result with the figures in the original groups, from which Fig. (8) was constructed, but before multiplication by reciprocals: it will be seen that the figures given by the modified method agree fairly well with the original figures. The position of the three chief subgroups is indicated fairly well if the draughtsman remembers to draw the curve on the

assumption that it is made up of components nearly symmetrical and of narrow spread. The curve is certainly superior, for the purposes of comparison with other curves, to the centimetre curve. It shows, however, that our original assumption that a frequency is equally distributed in its class-interval has an unnaturally "smoothing" effect and serves to emphasize the great superiority of ungrouped original data over originally grouped data.

Sources of Error in Computing l_1—l_2 etc. from Scales taken from Different Parts of the Fish.

By

Alf Dannevig and **Per Høst.**

The investigations are carried out at the laboratory of the Flødevig Sea-fish Hatchery with some subsidy from the Nansen Fond, Oslo.

On account of the great importance of scale examination, and the great amount of labour put into it, we are of opinion that the methods employed should be as strict as possible, so as to permit comparison of material compiled from different sources and by different persons. As things stand, this is not possible; every man has his own method both as to the sampling of scales and the deductions made.

When presenting this paper we want to draw attention to one special point, the differences in the computed sizes obtained when sampling the scales from different parts of the fish.

Though the means available are very restricted, and we are not able to base our examination of the problem on a great material, still we think the results arrived at are interesting enough to permit them to be published. We will especially draw attention to the great harmony between the different species. The general features found are likely to be governed by a common law.

Earlier investigators have shown that the calculated length of the fish l_1—l_2, etc., at the time when the different zones are laid down in the scales varies somewhat according to the locality from which the scale was taken.

Lea (1910) showed by the measurements of scales from herring that the l_1 increased on going towards the tail of the fish, but the variations were small; the probable error found on taking the scales from everywhere on the fish did not exceed 5 % for l_1. Lea is of opinion that the late formation of the scale in the pectoral region is chiefly to be held responsible to this phenomenon.

HUNTSMAN (1918) examined the scales of *Hippoglossoides platessoides* and found that a large tail-scale gave considerably greater values for l_1 than a scale from the pectoral region.

THOMPSON (1923) examined the scales from the haddock and came to the same result as LEA and HUNTSMAN. His conclusion is that the pectoral scales grow at first less, and finally more, than the flank scales.

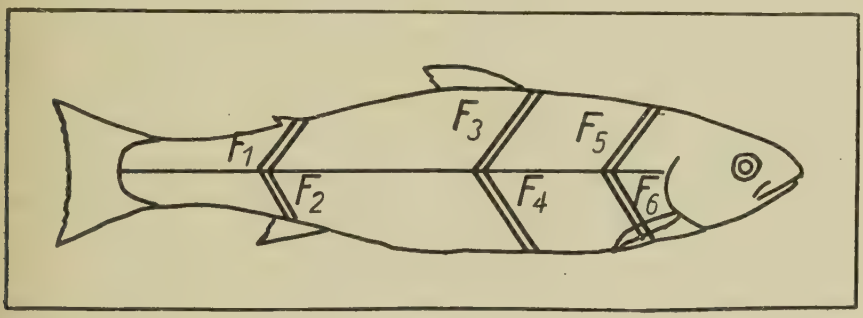


Fig. 1. Shôwing the areas from which the scales are taken for measurement in the Salmonidae.

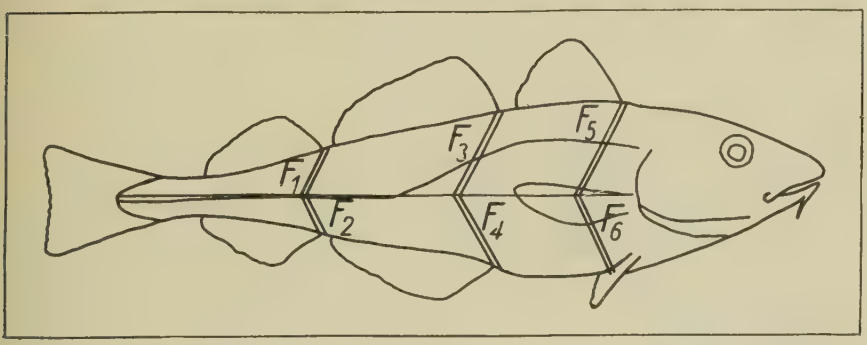


Fig. 2. Showing the areas from which the scales are taken for measurement in the Gadidae.

Dealing with cod, salmon and trout scales we felt it useful to examine this problem for the species mentioned, and for the sake of comparison also the scales of the haddock, green-cod and pollack were included.

The way of sampling the scales is shown in the figures 1 and 2. Along a straight line called the median line from the point of the gill cover to the middle of the caudal fin each fourth scale was collected. When a scale appeared to be imperfect the neighbouring one was secured.

Along the other lines examined every scale was put on the object-glass, the imperfect ones omitted and their numbers left open in the tables.

From the second cod examined, however, all scales were not sampled from the oblique lines; the material here was only meant as a supplement to that from the first cod examined.

The oblique lines are all taken from the median line previously described, up or downwards as far as good scales are found. In the case of the *Salmonidae* the F_5 and F_6 lines start from the 15th scale in the median line. The other lines are easily located by the figures 1 and 2.

When examining the scales, care was taken only to measure the zones which might be clearly followed and identified in the scales from all parts of the body examined. Zones relatively well-pronounced in some scales only were not taken into consideration.

The scales were all examined in EDINGER's projection apparatus, and measurements taken from the anterior part in the case of the *Salmonidae*, from the posterior part in the *Gadidae*.

First the examiner made a cursory survey of the material and then proceeded to the actual measurement.

By the aid of LEA's computing board (LEA 1915), the l_1—l_2—l_3 etc. were calculated, a direct proportionality being assumed, the arithmetic means were found, and the variation of the individual scales within each series put down in the tables.

In the figures illustrating the variations of the scales from the median line, the divergences are in percentages.

The material investigated is as follows:—

1) *Salmo salar* 320 mm. caught 6th of September 1929 in a lakelet in the mountains near Bygland (Setesdal) about 1500 feet above sea-level. Some salmon fry were brought up here in May 1926 from Kristiansand.
2) *Salmo salar* from Bornholm, examined in Oslo December 1929. Length 980 mm.
3) *Salmo fario* from the river Nidelv (Nisser) at the height of Nergaren in Åmli, 235 mm. long, caught on the 6th of July 1928.
4) *Gadus callarias*, caught near Arendal on the 17th of October 1929, length 660 mm.
5) *Gadus callarias II*, caught near Arendal on the 30th of October 1929, length 460 mm.
6) *Gadus virens*, caught near Arendal on the 14th of December 1929, length 500 mm.
7) *Gadus pollachius*, caught near Arendal on the 29th of October 1929, length 600 mm.
8) *Gadus aeglefinus*, caught near Arendal on the 30th of November 1929, length 580 mm.

The figures 3—10 confirm what has been found by the earlier investigators. On the whole, the l_1 increases as we pass from the pectoral region towards the tail, the few last scales omitted.

It is obvious, however, that in all species we find very great variations, especially in the pectoral region, some scales here giving the lowest numbers for l_1, and some very nearly the highest. The scales of the salmon from Bygland a short distance apart give values for l_1 varying from —15 % to +10 %. In the case of the cod from 17th of October the l_1 varies from about —35 % to +7 %.

From the same figures it will be seen that the values of l_2 and l_3 regularly vary in the same direction as l_1. This may be caused by the deficiency or excess of growth during the first year, the time of the formation of the scale here playing a great part. From the tables 1—8 it is evident, however, that the arithmetic differences (d), from the mean may increase in l_2 and even in l_3, indicating that the slower or quicker growth continues during several years. This is apparent from the accompanying table. Here the d-values of tables 1—8 are summed up for the foremost third of the scales of the median line.

	d_1	d_2	d_3	d_4
S. salar, Bygland	— 50	— 70	— 80	..
S. salar, Bornholm	— 35	— 68	—270	—155
S. fario	— 43	— 58	— 75	— 48
G. callarias 660 mm	—171	—124	— 63	—107
G. callarias 460 mm	—219	—100	—108	..
G. virens	—118	— 65	— 40	..
G. pollachius	—150	—137	—134	..
G. aeglefinus	—215	—213	— 37	—116

In the case of the salmon from Bygland the value of d increases, the margin of the scale alone compensating for the deficiency. As to the salmon from Bornholm the d_4-value is considerably smaller than the d_3, indicating that the scale has been growing relatively quickly in this part of the body in its 4th year. The trout shows the same. The d-values for the two cod, however, are constantly decreasing, just as with the coalfish and the pollack. The haddock, however, has a rise in the d_4.

It is evident that the change in the growth-rate of the scale in relation to the fish varies somewhat, but one thing is common to all species. The margin of the scale is in all cases a compensating factor of importance.

Tables 9—16 give the mean values for the different regions, the

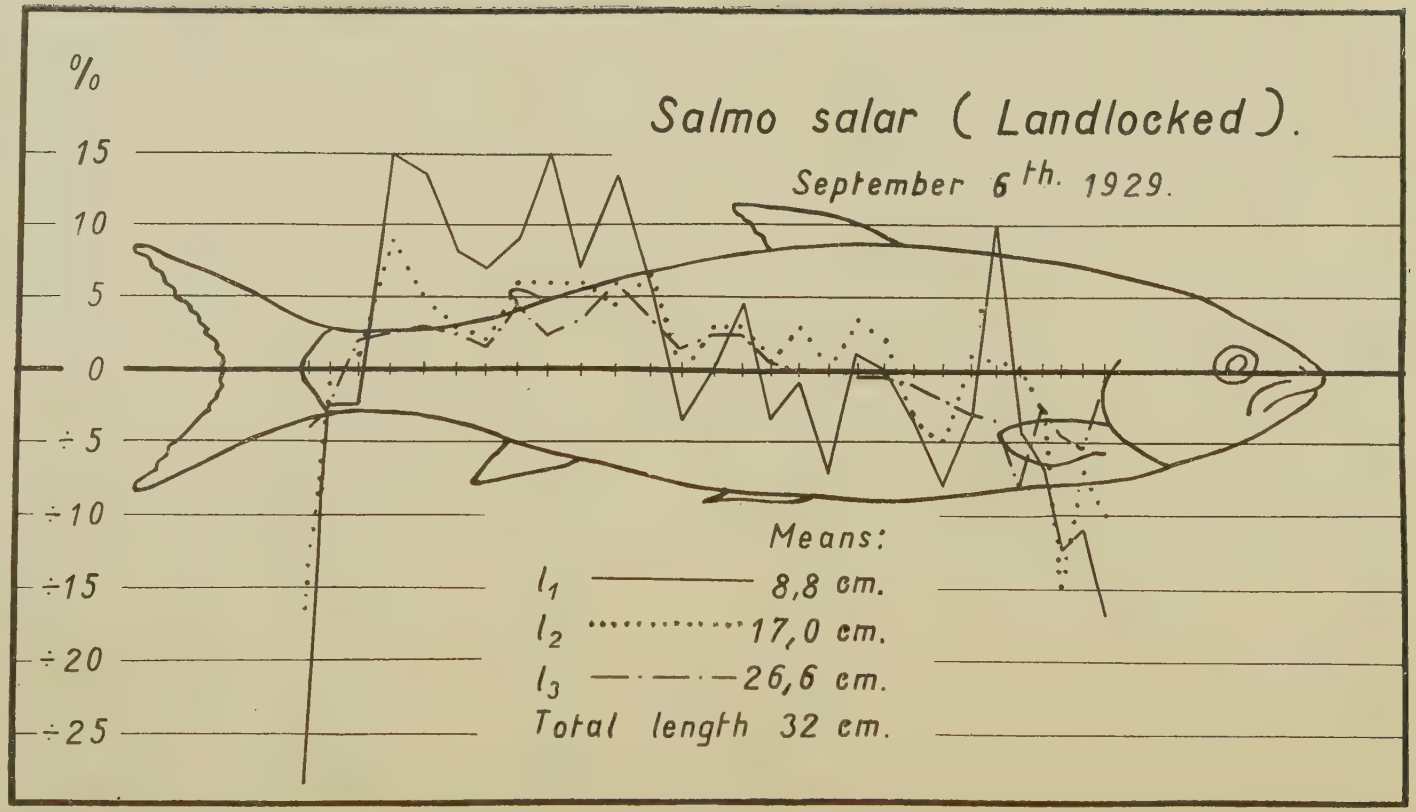

%
15
10
5
0
÷5
÷10
÷15
÷20
÷25
Salmo salar (Landlocked).
September 6th. 1929.
Means:
l1 8,8 cm.
l2 17,0 cm.
l3 26,6 cm.
Total length 32 cm.

Fig. 3.

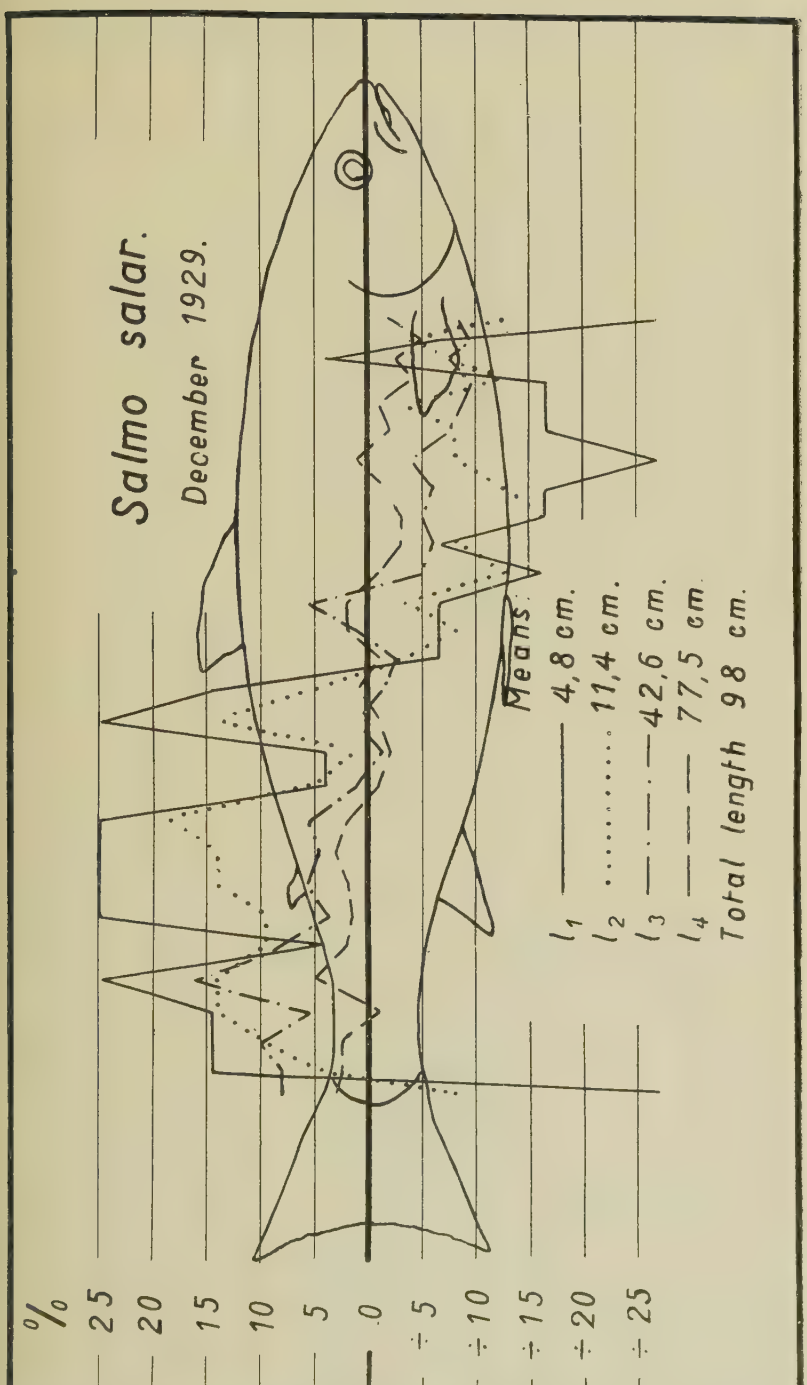

Salmo salar.
December 1929.
%
25
20
15
10
5
0
÷ 5
÷ 10
÷ 15
÷ 20
÷ 25
Means:
l_1 —— 4,8 cm.
l_2 ..... 11,4 cm.
l_3 —·—·— 42,6 cm.
l_4 — — — 77,5 cm.
Total length 98 cm.

Fig. 4.

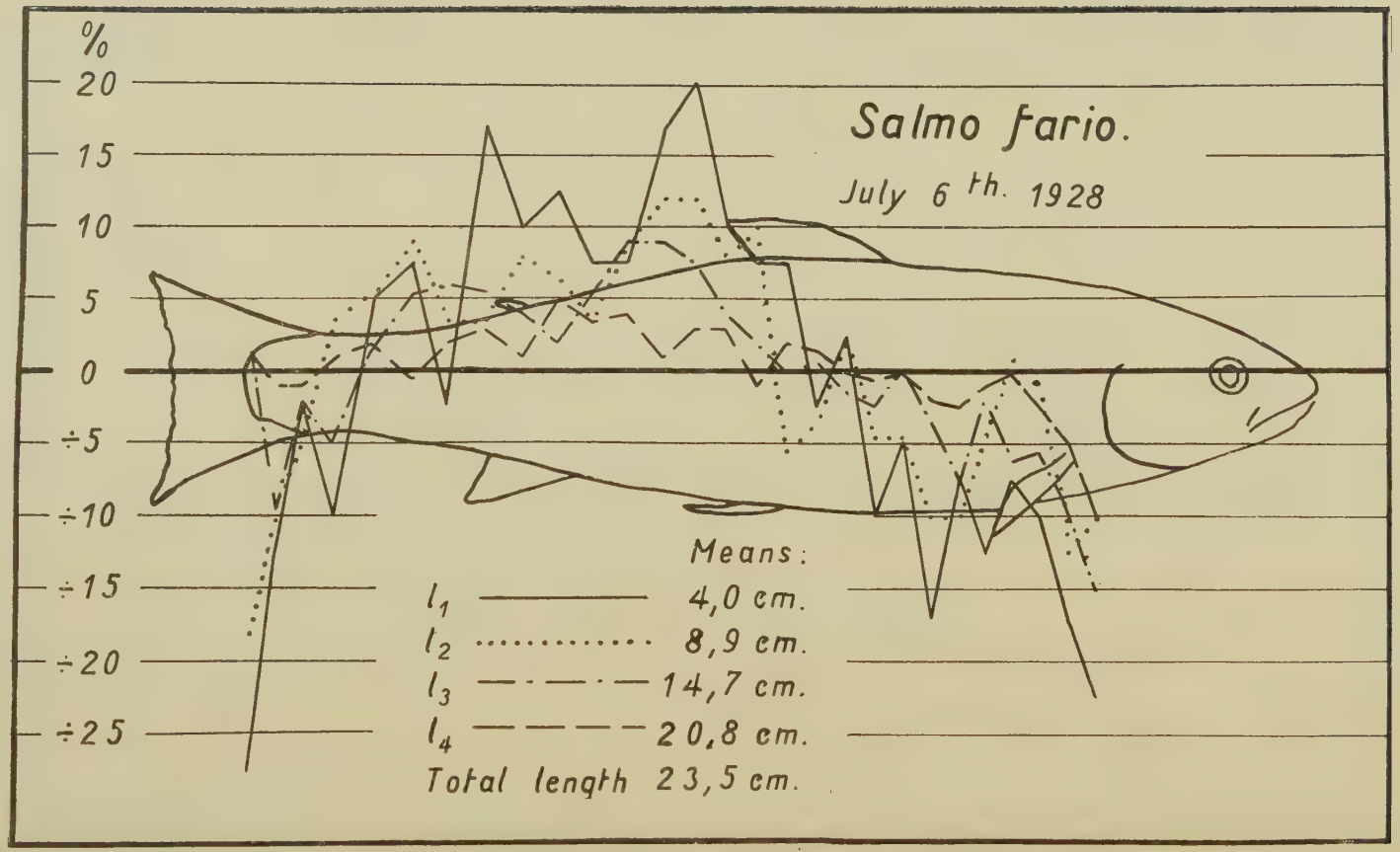

%
20
15
10
5
0
÷5
÷10
÷15
÷20
÷25
Salmo fario.
July 6 th. 1928
Means:
l_1 4,0 cm.
l_2 8,9 cm.
l_3 14,7 cm.
l_4 20,8 cm.
Total length 23,5 cm.

Fig. 5.

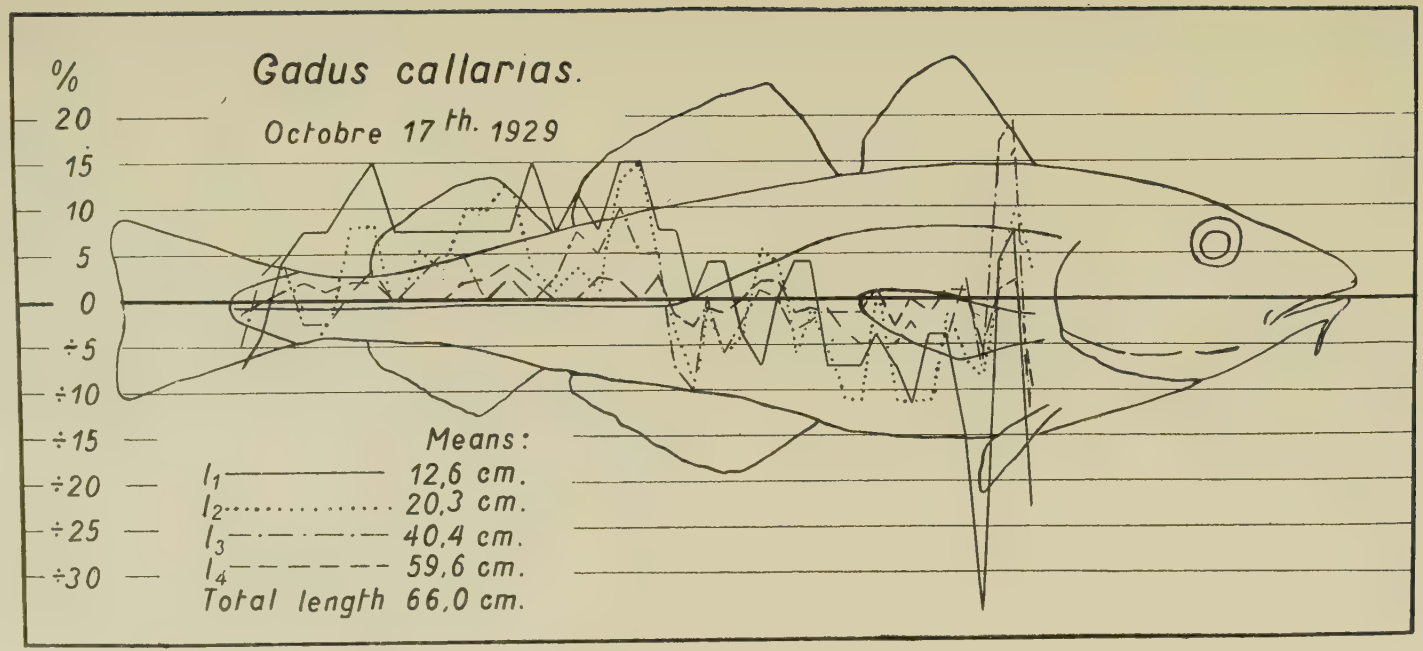

Gadus callarias.
Octobre 17 th. 1929
%
20
15
10
5
0
÷5
÷10
÷15
÷20
÷25
÷30
Means:
l_1 12,6 cm.
l_2 20,3 cm.
l_3 40,4 cm.
l_4 59,6 cm.
Total length 66,0 cm.

Fig. 6.

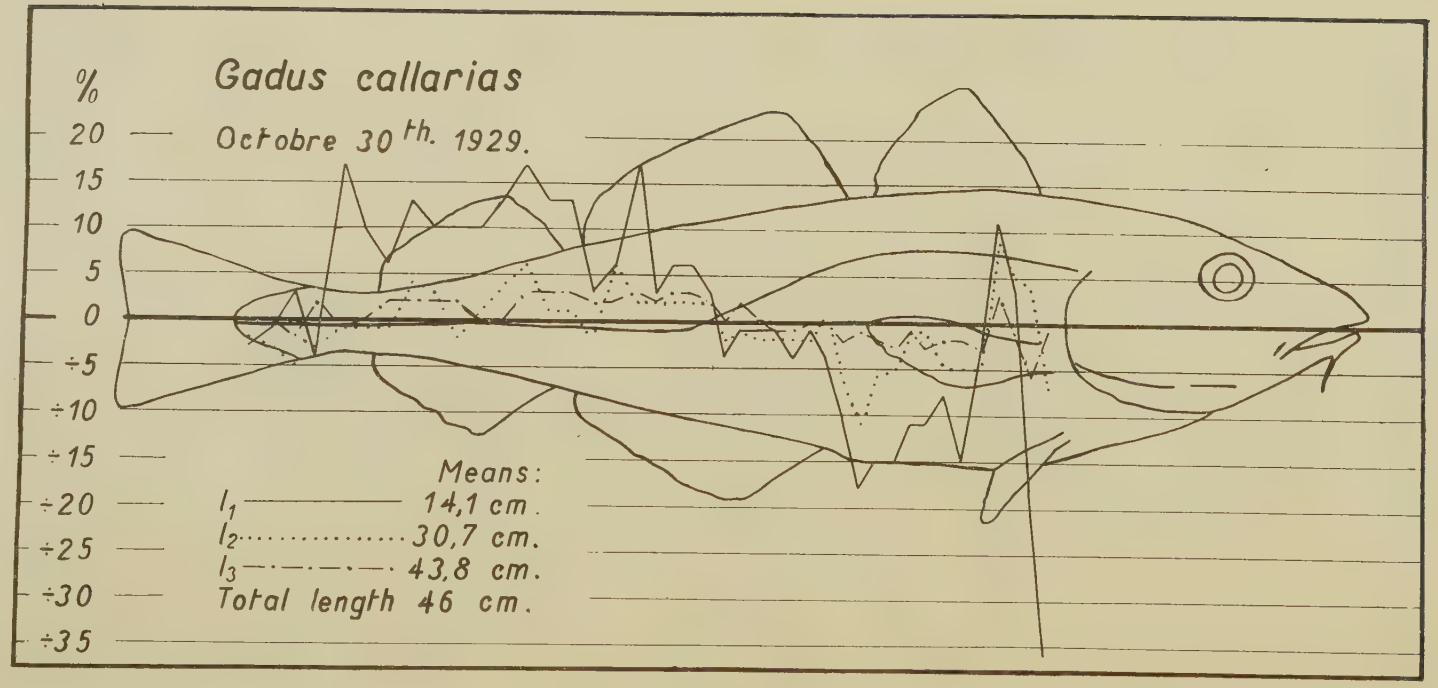

%
20
15
10
5
0
÷5
÷10
÷15
÷20
÷25
÷30
÷35
Gadus callarias
Octobre 30th. 1929.
Means:
l1 14,1 cm.
l2 30,7 cm.
l3 43,8 cm.
Total length 46 cm.

Fig. 7.

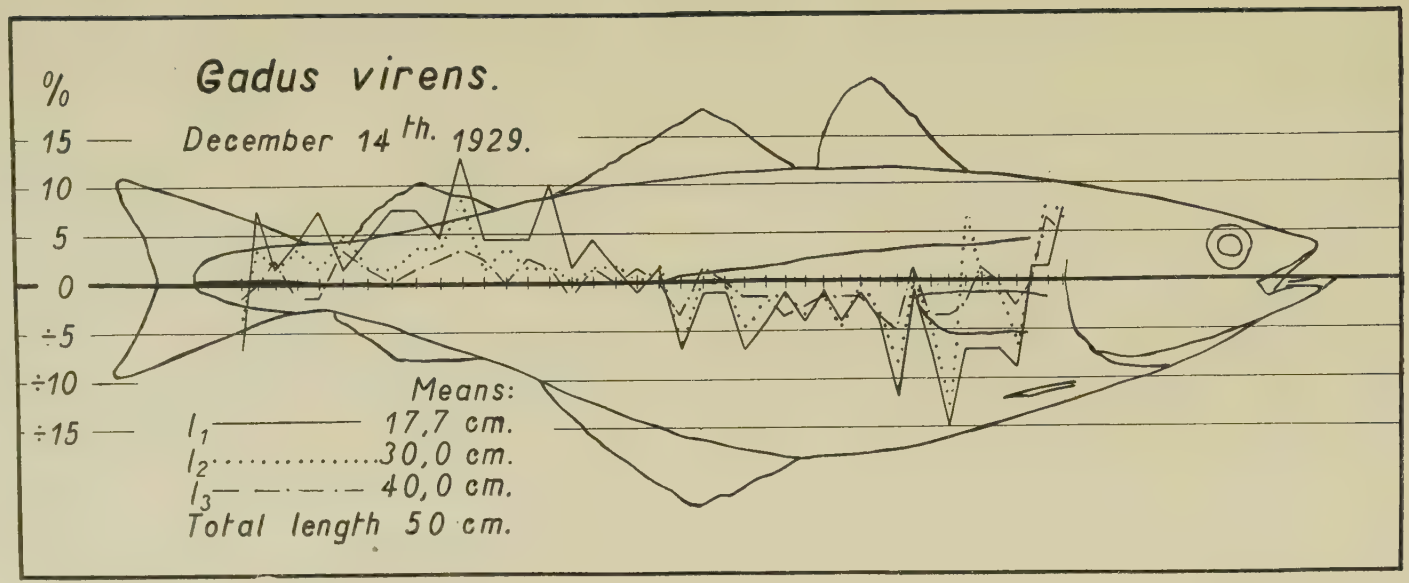

%
Gadus virens.
15
December 14th. 1929.
10
5
0
÷5
÷10
÷15
Means:
l_1 17,7 cm.
l_2 30,0 cm.
l_3 40,0 cm.
Total length 50 cm.

Fig. 8.

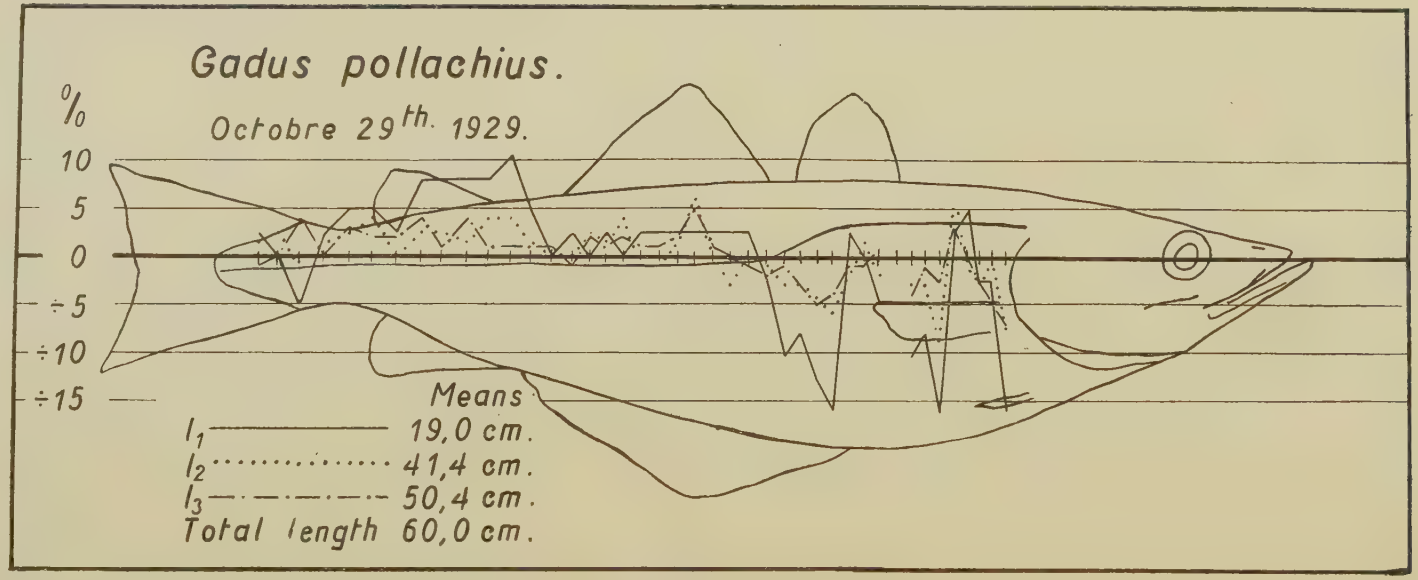

Gadus pollachius.
%
Octobre 29th. 1929.
10
5
0
÷5
÷10
÷15
Means
l1 19,0 cm.
l2 41,4 cm.
l3 50,4 cm.
Total length 60,0 cm.

Fig. 9.

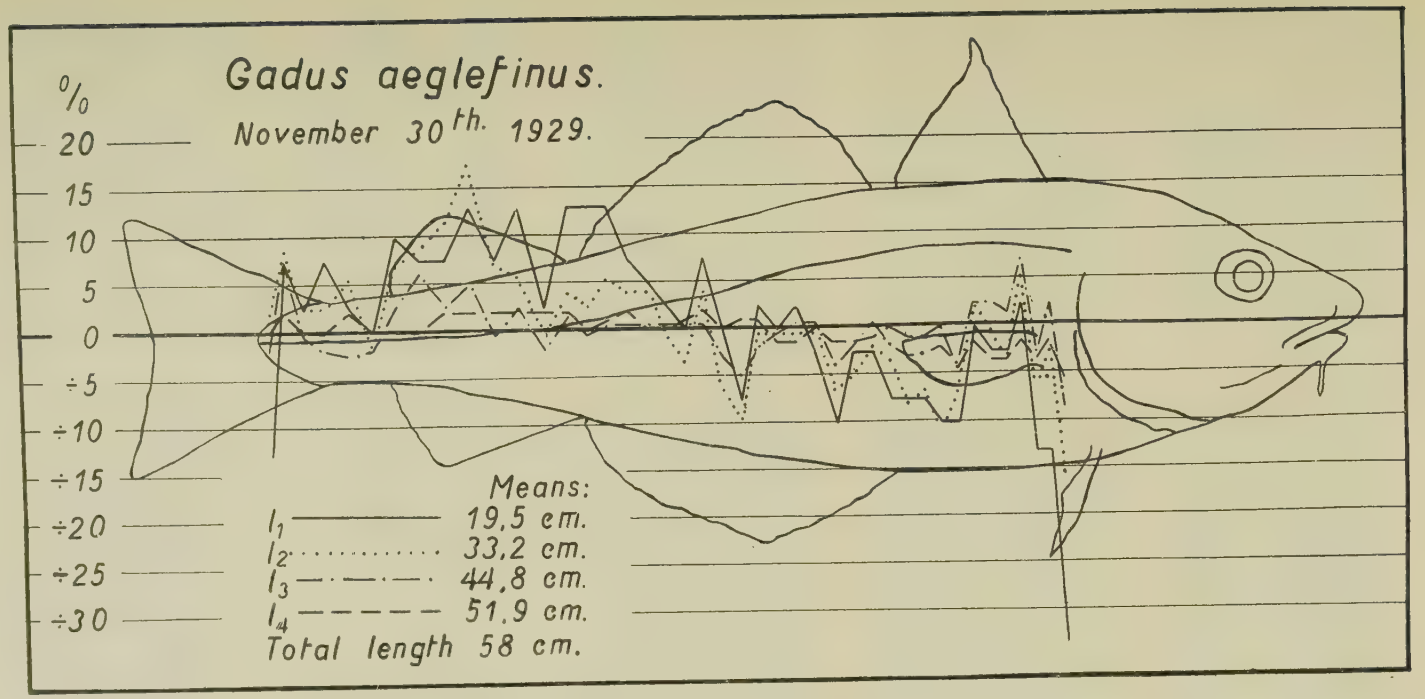

Gadus aeglefinus.
November 30th. 1929.
%
20
15
10
5
0
÷5
÷10
÷15
÷20
÷25
÷30
Means:
l_1 19,5 cm.
l_2 33,2 cm.
l_3 44,8 cm.
l_4 51,9 cm.
Total length 58 cm.

Fig. 10.

regions on the dorsal side of the median line F_1—F_3—F_5 are put at the top of the tables, the corresponding values from the ventral part F_2—F_4—F_6 are put beneath. The mean variation is also given.

The F-values fully confirm what is found by the previous examination of the scales of the median line.

The l_1 of the scales in the foremost part of the body always show lower values than from the posterior part, and the margin of the scale in all specimens plays a considerable part in compensating the less growth in earlier years. The relative growth of the margin is in all cases examined always greater in the anterior than in the posterior part of the fish. This may indicate that the formation of the zones is not quite simultaneous in the different parts of the body, or that at least the completion of the zones occurs later in the posterior part.

The causes of the great variation of the computed length of l_1 will not be discussed on the basis of this material. In order to solve that question we recommend that fish of the different species are kept in confinement and scales taken from different parts of the living individuals each month of the year.

The conclusion can be drawn, however, that in many species at least the scale does not grow in correspondence with the total length of the fish. Whether it grows in correspondence with the part of body in question we can not say. That the rate of growth of the scale is not in proportion to the total length of the cod has recently been shown by Duff (1929). During the principal time of growth of the cod in the Canadian waters, viz., May—July, the scales grow at a lower rate. The scale growth is at its highest in October when the growth of the fish has nearly ceased.

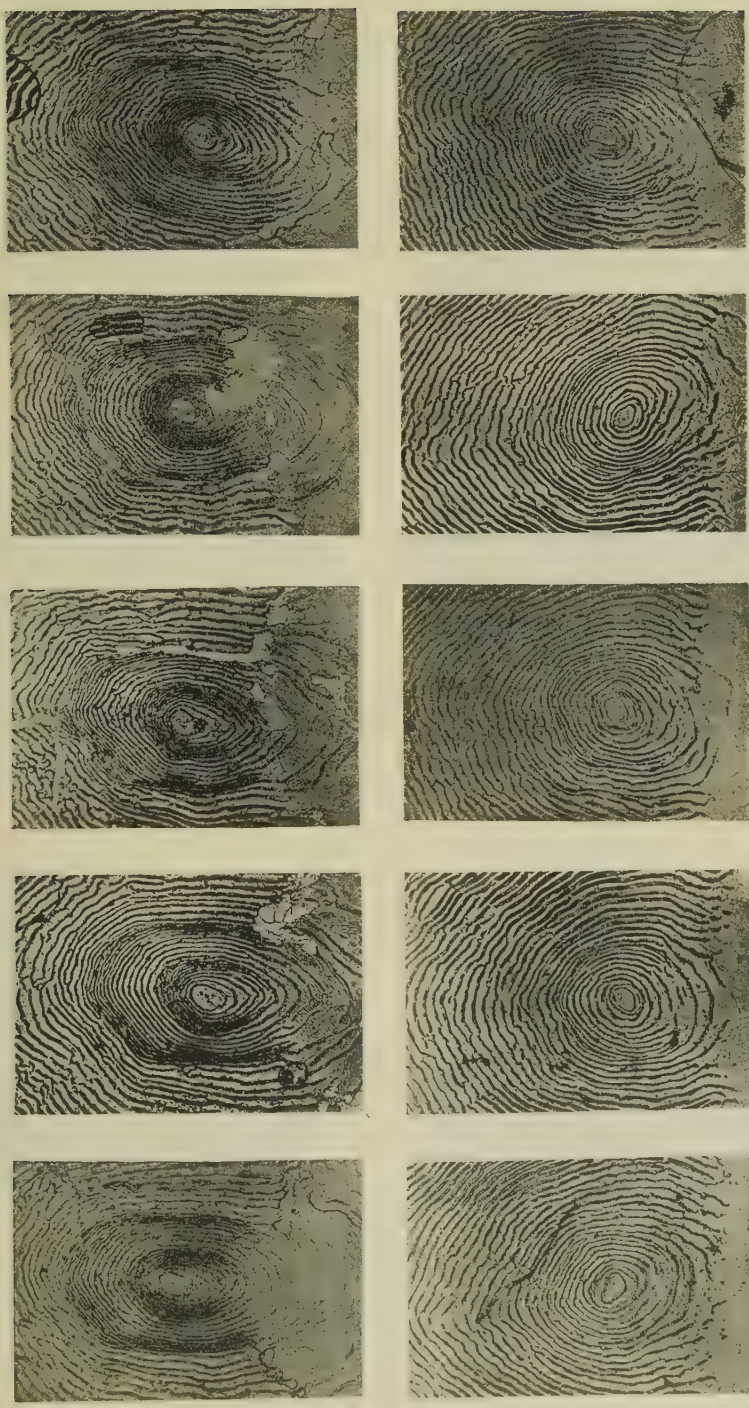
In connection with the question of the change in the growth-rate of the scale, it is interesting to study the measurements of Curt Segerstråle on *Leuciscus rutilus*. The measurements of the zones in the anterior part of the scale showed this phenomenon quite distinctly; in the caudal part the values were constant.

In tables 9—16 are included the numbers giving the mean variation of the computed length for l from scales from different parts of the body.

For the sake of convenience the variations are here summed up for each area[1]). The values are:—

[1]) In this method the different species ought not to be compared with each other, nor different individuals of the same species, except when of the same age.

F1 F6



o. 4. No. 5.

o. 5. No. 6.

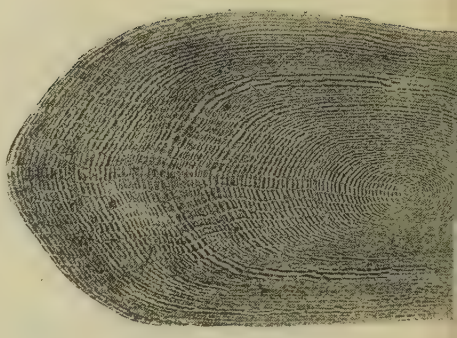
o. 6. No. 7.

o. 7. No. 8.

o. 8 No. 9.

Plate I. Salmo salar (Bornholm).

F1 (No. 1).



F6 No 14.

F1 No. 2.

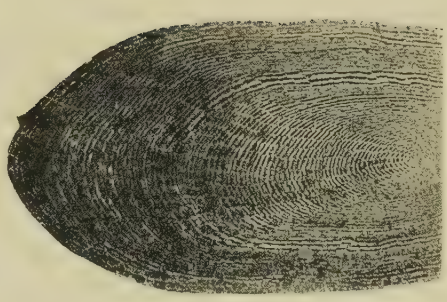
F6 No. 15.

F1 No. 4.

F6 No. 16.

Plate II (a).
Gadus pollachius.

F1 No. 5.

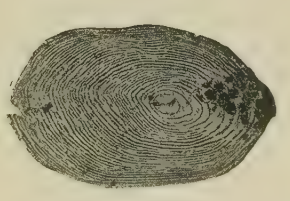


F6 No. 24.

F1 No. 6.

F6 No. 25.

F1 No. 3.



F5 No. 22.

Plate II (b).
Gadus pollachius and Salmo fario (the two at bottom).

	F_1	F_2	F_3	F_4	F_5	F_6
S. salar	14.0	*11.9*	17.8	15.7	16.2	**23.7**
S. salar II	*29.3*	31.0	44.4	41.5	53.1	**71.6**
S. fario	12.5	*10.3*	16.9	19.8	**28.4**	16.4
G. callarias	34.8	36.9	*32.1*	43.1	**64.0**	44.8
G. callarias II	*12.0*	17.0	18.8	21.2	12.7	**29.6**
G. virens	*19.5*	26.3	24.2	25.7	28.9	**40.9**
G. pollachius	31.7	30.0	*29.7*	32.4	33.0	**43.1**
G. aeglefinus	45.7	42.3	*37.2*	**49.2**	39.3	44.2

It is evident that the smallest variation occurs in the oblique lines F_1—F_2—F_3 and the greatest in F_4—F_5—F_6, a point worth mention when the question arises of the position from which to take the scale sample on the fish. The detailed measurements from the oblique lines show that the variations are less pronounced near the median line.

As to the different species we want to say a few words on the scales of the salmon, trout and the pollack. The cod scales will be dealt with in another paper.

It has been mentioned previously that the values of l_1 are always very small in the pectoral region. In the case of the salmon from Bornholm the l_1 quite disappears in many scales in the area F_6 (Plate I) and exceptionally in F_5. In the case of the trout the same often happens in the area F_5 (Plate II).

This phenomenon is of very great importance, and it indicates that the English fashion of taking the scale from the "shoulder" of the salmon and trout ought not to be copied in northern waters. It may be that the method holds good in the English waters, where the scale will probably attain during the first year a size great enough to have the first zone formed. But this is not so in northern waters.

The phenomenon of very small, scarcely detectable, first "Winter zones" in the scales of the salmon has previously been described by Arwidson (1910) and by Dannevig (1928). It was shown by the latter that the "Winter zones" of the young salmon from the south of Norway were always laid down in late summer, at a time when a part of the young salmon was not big enough to have well developed scales.

Looking at the figures on Plate I it is evident that the zones in the scales from the pectoral region are indistinct and very narrow in relation to the zones in the scales from the tail region. Inspection of the scales from the median line shows that the one type regularly passes over to the other as we proceed backwards on the fish. The differences in appearence make it very likely that the mode of growth may be different.

In the trout scales we also find the same difference between the pectoral part and the tail of the fish.

The Gadidae also have scales with very narrow first zones, especially in the dorsal part of F_5. This locality ought therefore to be omitted when sampling scales, especially in waters where the growth during the first year is small.

In the case of the pollack (Plate II)[1]) the scales from the pectoral region have a tendency to form supernumerary zones, especially in the outer part. In the F_1 series we have three conspicuous zones; in the F_6 we may count 5 or 6 zones. Compare, for example, F_6 no. 16 and F_1 no. 4.

This feature, however, is much more pronounced when examining the scales than when looking at the photographs. By noticing the zones in the scales from the tail towards the head we can follow the supernumerary zones coming gradually into prominence.

Summary.

From the examination of the scales from different parts of the fish of the species *Salmo salar*, *S. fario*, *Gadus callarias*, *G. virens*, *G. pollachius* and *G. aeglefinus* it is shown that the computed lengths of the fish when the different zones are formed varies in accordance with the locality from which the scale is taken.

This is in conformity with the results of earlier investigators in the case of *Cl. harengus*, *G. aeglefinus* and *Hippoglossoides platessoides*.

The last scales on the tail omitted, the values computed from the early zones in the scales, the l_1, the l_2 and l_3 decrease forwards. The later zones, and especially the margin, increase.

In the case of the salmon and the trout examined the l_1 may disappear in scales from the pectoral region.

Scales from that part of the body are thus apparently not able to give the true age of the fish in our waters.

On account of the very pronounced "secondary minima", the scales from the pectoral region of the pollack may give more annuli than the scales from the caudal part.

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[1]) The scale F_1, no. I, not being good the neighbouring scale was photographed.

Tables.

Tables 1—8 give the computed lengths (l) and increments (t) from approximately each fourth scale along a straight line, the median line, from gill-cover to the tail.

Tables 9—16 give the computed mean length for l for the different oblique lines, with the mean variations. The mean variation for l_1—l_2, etc. are summed to give an idea in which area the variation is least or greatest. The detailed tables for the oblique lines are not printed.

Table 1. Salmo salar L. 320 mm. Bygland.
Median line.

No. of scale examined	l_1	d	l_2	d	l_3	d	t_1	t_2	t_3	Mrg.
1.....	73	—15	153	—17	265	—1	73	80	112	55
2.....	78	—10	158	—12	252	—14	78	80	94	68
3.....	77	—11	144	—26	254	—12	77	67	110	66
4.....	82	—6	165	—5	260	—6	82	83	95	60
5.....	84	—4	170	0	245	—21	84	86	75	75
6.....	97	9	171	1	257	—9	97	74	86	63
7.....	85	—3	172	2	258	—8	85	87	86	62
8.....	81	—7	160	—10	261	—5	81	79	101	59
9.....	85	—3	164	—6	263	—3	85	79	99	57
10.....	88	0	173	3	265	—1	88	85	92	55
11.....	89	1	176	6	265	—1	89	87	89	55
12.....	82	—6	170	0	266	0	82	88	96	54
13.....	87	—1	175	5	266	0	87	88	91	54
14.....	85	—3	171	1	267	1	85	86	96	53
15.....	92	4	175	5	272	6	92	83	97	48
16.....	88	0	175	5	273	7	88	87	98	47
17.....	85	—3	169	—1	270	4	85	84	101	50
18.....	93	5	181	11	275	9	93	88	94	45
19.....	100	12	178	8	282	16	100	78	104	38
20.....	94	6	180	10	275	9	94	86	95	45
21.....	101	13	180	10	273	7	101	79	93	47
22.....	96	8	180	10	278	12	96	84	98	42
23.....	94	6	173	3	270	4	94	79	97	50
24.....	95	7	175	5	272	6	95	80	97	48
25.....	100	12	178	8	274	8	100	78	96	46
26.....	101	13	185	15	272	6	101	84	87	48
27.....	86	—2	172	2	271	5	86	86	99	49
28.....	86	—2	168	—2	260	—6	86	82	92	60
29.....	64	—22	142	—28	256	—10	64	78	114	64
Mean:										
Length ...	88	..	170	..	266	..	..	..	..	..
Variation..	..	6.7	..	7.5	..	6.8	..	..	..	..

Table 2. Salmo salar L. 980 mm. Bornholm.
Median line.

No. of scale examined	l_1	d	l_2	d	l_3	d	l_4	d	t_1	t_2	t_3	t_4	Mrg.
2.....	35	13	100	14	390	—35	760	—15	35	65	290	370	220
3.....	45	3	110	—4	385	—40	735	—40	45	65	275	355	245
4.....	50	2	105	—9	395	—30	755	—20	50	55	290	360	225
5.....	40	—8	100	—14	385	—40	745	—30	40	60	285	360	235
6.....	40	—8	110	—4	390	—35	770	—5	40	70	280	380	210
7.....	40	—8	105	—9	395	—30	760	—15	40	65	290	365	220
8.....	35	—13	105	—9	410	—15	780	5	35	70	305	370	200
9.....	40	—8	100	—14	400	—25	765	—10	40	60	300	365	215
10.....	40	—8	95	—19	405	—20	750	—25	40	55	310	345	230
11.....	45	—3	105	—9	400	—25	755	—20	45	60	295	355	225
12.....	40	—8	100	—14	405	—20	770	—5	40	60	305	365	210
13.....	45	—3	110	—4	450	25	790	15	45	65	340	340	190
14.....	45	—3	105	—9	430	5	790	15	45	60	335	360	190
15.....	45	—3	110	—4	415	—10	770	—5	45	65	305	355	210
16.....	55	7	120	6	420	—5	780	5	55	65	300	360	200
17.....	60	12	130	16	430	5	770	—5	60	70	300	340	210
18.....	50	2	115	1	420	—5	760	—15	50	65	305	340	220
19.....	50	2	120	6	430	5	770	—5	50	70	310	340	220
20.....	60	12	135	21	450	25	790	15	60	75	315	340	190
21.....	60	12	130	16	445	20	800	25	60	70	315	355	180
22.....	60	12	130	16	450	25	790	15	60	70	320	340	190
23.....	60	12	125	11	440	15	785	10	60	65	315	345	195
24.....	50	2	125	11	460	35	790	15	50	75	335	330	190
25.....	60	12	130	16	495	70	815	40	60	70	365	320	165
26.....	55	7	130	16	450	25	770	5	55	75	320	320	210
27.....	55	7	125	11	470	45	795	20	55	70	345	325	185
28.....	55	7	120	6	460	35	795	20	55	65	340	335	185
29.....	35	—13	105	—9	460	35	800	25	35	70	355	340	180
Mean:													
Length ...	48	..	114	..	426	..	775	..	..	..	..	..	..
Variation..	..	7.5	..	10.3	..	25.2	..	15.9	..	..	..	..	..

Table 3. Salmo fario L. 235 mm. Åmli.
Median line.

No. of scale examined	l_1	d	l_2	d	l_3	d	l_4	d	t_1	t_2	t_3	t_4	Mrg.
1.....	32	—8	80	—12	125	—22	187	—21	32	48	45	62	48
2.....	33	—7	78	—10	133	—14	198	—10	33	45	55	65	37
3.....	36	—4	88	—2	139	—8	203	—5	36	52	51	64	32
4.....	37	—3	90	0	138	—9	208	0	37	53	48	70	27
5.....	35	—5	86	—4	144	—3	206	—2	35	51	58	62	29
6.....	37	—3	80	—10	137	—10	203	—5	37	43	57	66	32
7.....	33	—7	80	—10	142	—5	204	—4	33	43	62	62	31
8.....	38	—2	85	—5	148	1	208	0	38	47	63	60	27
9.....	36	—4	85	—5	143	—5	207	—1	36	51	58	64	28
10.....	41	1	91	1	145	—2	208	0	41	50	54	63	27
11.....	39	—1	86	—4	148	1	211	3	39	47	62	63	24
12.....	43	3	94	4	147	0	212	4	43	51	53	65	23
13.....	43	3	98	8	150	3	206	—2	43	55	52	56	29
14.....	44	4	96	6	153	6	214	6	44	52	57	61	21
15.....	48	8	100	10	158	11	214	6	48	52	58	56	21
16.....	47	7	100	10	160	13	210	2	47	53	60	50	25
17.....	43	3	97	7	160	13	217	9	43	54	63	57	18
18.....	45	5	92	2	155	12	215	7	45	47	63	60	20
19.....	43	3	95	5	150	3	218	10	43	52	55	68	17
20.....	46	6	96	6	153	6	210	2	46	50	57	57	25
21.....	48	8	92	2	155	8	214	6	48	44	63	59	21
22.....	41	1	92	2	156	9	212	4	41	57	64	56	23
23.....	44	4	97	7	155	8	207	—1	44	53	58	52	28
24.....	42	2	94	4	149	2	212	4	42	52	55	63	23
25.....	38	—2	92	2	140	—7	210	2	38	64	48	70	25
26.....	39	—1	80	—10	133	—14	206	—2	39	41	53	73	29
27.....	35	—5	85	—5	144	—3	206	—2	35	50	59	62	29
28.....	29	—11	73	—17	149	2	209	1	29	44	76	60	26
Mean:													
Length ...	40	..	90	..	147	..	208	..	..	..	..	..	..
Variation..	..	4.3	..	6.1	..	7.1	..	4.3	..	..	..	..	..

Table 4. Gadus callarias L. 660 mm.
Median line.

No. of scale examined	l_1	d	l_2	d	l_3	d	l_4	d	t_1	t_2	t_3	t_4	Mrg.
1.....	100	—32	220	7	360	—51	545	—54	100	120	140	185	115
2.....	140	8	235	22	490	79	610	11	140	95	255	120	50
3.....	135	3	220	7	480	69	605	6	135	85	260	125	55
4.....	85	—47	195	—18	380	—31	565	—34	85	110	185	185	95
7.....	110	—22	200	—13	420	9	605	6	110	90	220	185	55
8.....	125	—7	210	—3	390	—21	605	6	125	85	180	215	55
9.....	125	—7	190	—23	390	—21	590	—9	125	65	200	200	70
10.....	115	—17	190	—23	400	—11	600	1	115	75	210	200	60
11.....	120	—12	190	—23	390	—21	580	—19	120	70	200	190	80
12.....	125	—7	215	2	390	—21	605	6	125	90	175	215	55
13.....	120	—12	190	—23	390	—21	590	—9	120	70	200	200	70
14.....	120	—12	190	—23	395	—16	590	—9	120	70	195	195	70
15.....	120	—12	200	—13	405	—6	590	—9	120	80	185	185	70
16.....	135	3	210	—3	400	—11	595	—4	135	75	195	195	65
17.....	135	3	200	—13	395	—16	590	—9	135	65	195	195	70
18.....	130	—2	220	7	410	—1	610	11	130	90	200	200	50
19.....	120	—12	225	12	415	4	610	11	120	105	195	195	50
20.....	125	—7	205	—8	400	—11	600	1	125	80	200	200	60
21.....	135	3	200	—13	385	—26	590	—9	135	65	215	205	70
22.....	135	3	210	—3	410	—1	595	—4	135	75	185	185	65
23.....	130	—2	195	—18	370	—41	580	—19	130	65	175	210	80
24.....	140	8	205	—8	380	—31	590	—9	140	65	175	210	70
25.....	140	8	220	7	430	19	615	16	140	80	210	185	45
26.....	150	18	245	32	430	19	600	1	150	95	185	170	60
27.....	150	18	240	27	450	39	610	11	150	90	210	160	50
28.....	140	8	215	2	430	19	615	16	140	75	215	185	45
29.....	145	13	220	7	440	29	600	1	145	75	220	160	60
30.....	140	8	215	2	420	9	600	1	140	75	205	180	60
31.....	150	18	220	7	410	—1	610	11	150	70	190	200	50
32.....	140	8	240	27	420	9	620	21	140	100	180	200	40
33.....	140	8	235	22	410	—1	615	16	140	95	175	205	45
34.....	140	8	235	22	430	19	610	11	140	95	195	180	50
35.....	140	8	220	7	430	19	600	1	140	80	210	170	60
36.....	140	8	225	12	420	9	600	1	140	85	195	180	60
37.....	140	8	210	—3	410	—1	600	1	140	70	200	190	60
38.....	150	18	230	17	425	14	610	11	150	80	195	185	50
39.....	145	13	230	17	415	4	610	11	145	85	185	195	50
40.....	140	8	205	—8	400	—11	605	6	140	65	195	205	55
41.....	140	8	210	—3	400	—11	610	11	140	70	190	210	50
42.....	135	3	220	7	430	19	605	6	135	85	210	175	55
43.....	125	—7	200	—13	420	9	600	1	125	75	220	180	60
44.....	120	—12	210	—3	390	—21	590	—9	120	90	180	200	70
Mean:													
Length ...	132	..	213	..	411	..	599	..	..	..	..	..	..
Variation .		8.4	..	10.2	..	19.1	..	10.0	..	..	..	..	..

Table 5. Gadus callarias L. 460 mm.

Median line

No. of scale examinated	l_1	d	l_2	d	l_3	d	t_1	t_2	t_3	Mrg.
1.....	90	—51	280	—35	435	—4	90	190	155	25
3.....	115	—26	320	15	415	—24	115	195	95	45
4.....	145	4	325	20	430	—9	145	180	105	30
5.....	155	14	340	35	445	6	155	185	105	15
6.....	135	—6	290	—15	425	—14	135	155	135	35
7.....	120	—21	290	—15	430	—9	120	170	140	30
8.....	130	—11	290	—15	430	—9	130	160	140	30
9.....	125	—16	305	0	425	—14	125	180	120	35
10.....	125	—16	305	0	435	4	125	180	130	25
11.....	120	—21	290	—15	425	—14	120	170	135	35
12.....	120	—21	285	—20	430	—9	120	165	145	30
13.....	115	—26	265	—40	435	—4	115	150	170	25
14.....	125	—16	285	—20	430	—9	125	160	145	30
15.....	135	—6	310	5	440	1	135	175	130	20
16.....	140	—1	300	—5	440	1	140	160	140	20
17.....	135	—6	300	—5	435	—4	135	165	135	25
18.....	140	—1	300	—5	435	—4	140	160	135	25
19.....	140	—1	300	—5	440	1	140	160	140	20
20.....	140	—1	305	—5	445	6	140	165	140	15
21.....	135	—6	300	5	440	1	135	165	140	20
22.....	145	4	315	10	445	6	145	170	130	15
23.....	150	9	315	10	450	11	150	165	135	10
24.....	150	9	315	10	450	11	150	165	135	10
25.....	145	4	315	10	445	6	145	170	130	15
26.....	165	24	315	10	450	11	165	150	135	10
27.....	150	9	330	25	445	6	150	180	115	15
28.....	145	4	300	—5	445	6	145	155	145	15
29.....	160	19	310	5	450	11	160	150	140	10
30.....	160	19	310	5	450	11	160	150	140	10
31.....	165	24	330	25	450	11	165	165	120	10
32.....	160	19	320	15	440	1	160	160	120	20
33.....	155	14	310	5	440	1	155	155	130	20
34.....	155	14	305	0	445	6	155	150	140	15
35.....	155	4	310	5	445	6	155	155	135	15
36.....	160	19	320	15	445	6	160	160	125	15
37.....	150	9	305	0	445	6	150	155	140	15
38.....	155	14	305	0	440	1	155	150	135	20
39.....	165	24	305	0	435	—4	165	140	130	25
40.....	135	—6	295	—10	445	6	135	160	150	15
41.....	145	4	290	—15	430	—9	145	145	140	30
42.....	140	—1	295	—10	440	1	140	155	145	20
43.....	135	—6	300	5	435	—4	135	165	135	25
Mean:										
Length ...	141	..	305	..	439	..	..	..	..	..
Variation..	..	12.6	..	11.3	..	6.9	..	..	..	..

Table 6. Gadus virens L. 500 mm.
Median line.

No. of scale examined	l_1	d	l_2	d	l_3	d	t_1	t_2	t_3	Mrg.
1.....	190	13	320	20	420	20	190	130	100	80
2.....	180	3	325	25	425	25	180	145	100	75
3.....	180	3	300	0	400	0	180	120	100	100
4.....	160	—17	280	—20	390	—10	160	120	110	110
5.....	165	—12	295	—5	400	0	165	130	105	100
6.....	165	—12	300	0	405	5	165	135	105	95
7.....	165	—12	320	20	390	—10	165	155	70	110
8.....	150	—27	260	—40	385	—15	150	110	125	115
9.....	165	—17	285	—15	385	—15	165	120	100	115
10.....	175	—2	300	0	405	5	175	125	105	95
11.....	155	—22	275	—25	380	—20	155	120	105	120
12.....	170	—7	290	—10	385	—15	170	120	95	115
13.....	175	—2	300	0	395	—5	175	125	95	105
14.....	170	—7	285	—15	395	—5	170	115	100	105
15.....	175	—2	295	—5	395	—5	175	120	100	105
16.....	170	—7	290	—10	390	—10	170	120	100	110
17.....	175	—2	295	—5	385	—15	175	120	90	115
18.....	170	—7	295	—5	395	—5	170	125	100	105
19.....	165	—12	285	—15	395	— 5	165	120	100	105
20.....	175	—2	300	0	400	0	175	125	100	100
21.....	175	—2	300	0	405	5	175	125	105	95
22.....	165	—12	280	—20	385	—15	165	115	105	115
23.....	180	3	305	5	400	0	180	125	95	100
24.....	175	—2	300	0	405	5	175	125	105	95
25.....	180	3	305	5	400	5	180	125	95	100
26.....	185	8	305	5	405	5	185	120	100	95
27.....	180	3	300	0	395	—5	180	120	95	105
28.....	195	18	305	5	405	5	195	110	100	95
29.....	185	8	305	5	410	10	185	120	105	90
30.....	185	8	310	10	400	0	185	125	90	100
31.....	185	8	305	5	410	10	185	120	105	90
32.....	200	23	325	25	415	15	200	125	90	85
33.....	185	8	310	10	410	10	185	125	100	90
34.....	190	13	310	10	405	5	190	120	105	95
35.....	190	13	305	5	400	0	190	115	95	100
36.....	185	8	305	5	405	5	185	120	100	95
37.....	180	3	315	15	415	15	180	135	100	85
38.....	190	13	305	5	395	—5	190	115	90	105
39.....	185	8	310	10	395	—5	185	125	85	105
40.....	180	3	305	5	410	10	180	125	105	90
41.....	190	13	310	10	400	0	190	120	90	100
42.....	165	—12	290	—10	395	—5	165	125	105	105
Mean:										
Length ...	177	..	300	..	400	..	..	..	..	..
Variation..	..	9.0	..	9.7	..	7.9	..	..	..	..

Table 7. Gadus pollachius L. 600 mm.
Median line.

No. of scale examined	l_1	d	l_2	d	l_3	d	t_1	t_2	t_3	Mrg.
1.....	160	—30	380	—34	470	—34	160	220	90	130
2.....	185	—5	415	1	480	—24	185	230	65	120
3.....	185	—5	400	—14	490	—14	185	215	90	110
4.....	200	10	410	—4	505	1	200	210	95	95
5.....	195	5	440	26	520	16	195	245	80	80
6.....	160	—30	385	—29	485	—19	160	225	100	115
7.....	175	—15	400	—14	500	4	175	225	100	100
8.....	170	—20	400	—14	485	—19	170	230	85	115
10.....	180	—10	405	—9	510	6	180	225	105	110
11.....	190	0	420	6	500	—4	190	230	80	100
12.....	195	5	405	—9	500	—4	195	210	95	100
13.....	160	—30	390	—24	485	—19	160	230	95	115
14.....	165	—25	395	—19	480	—24	165	230	85	120
15.....	175	—15	400	—14	490	—14	175	225	90	110
16.....	170	—20	400	—14	500	—4	170	230	100	.100
17.....	185	—5	410	—4	495	—9	185	225	85	105
18.....	195	5	415	1	500	—4	195	220	85	100
19.....	195	5	400	—14	505	1	195	205	105	95
20.....	195	5	415	1	510	6	195	220	95	90
21.....	195	5	440	26	530	24	195	245	90	70
22.....	195	5	420	6	515	11	195	225	95	85
23.....	195	5	410	—4	510	6	195	215	100	90
24.....	195	5	410	—4	510	6	195	215	100	90
25.....	190	0	430	16	515	11	190	240	85	85
26.....	195	5	420	6	510	6	195	225	90	90
27.....	190	0	425	11	515	11	190	235	90	85
28.....	195	5	415	1	500	—4	195	220	85	100
29.....	190	0	415	1	510	6	190	225	95	90
30.....	200	10	420	6	510	6	200	220	90	90
31.....	210	20	430	16	510	6	210	220	80	90
32.....	205	15	430	16	510	6	205	225	80	90
33.....	205	15	420	4	525	21	205	215	105	75
34.....	205	15	425	11	510	6	205	220	85	90
35.....	205	15	425	11	525	21	205	220	100	75
36.....	195	5	420	6	515	11	195	225	95	85
37.....	200	10	430	16	515	11	200	230	85	85
38.....	200	10	425	11	520	16	200	225	95	80
39.....	195	5	420	6	505	1	195	225	85	95
40.....	180	—10	410	—4	485	19	180	230	75	115
41.....	190	0	425	11	505	1	190	235	80	95
42.....	195	5	420	6	500	—4	195	225	80	100
Mean:										
Length ...	190	..	414	..	504	..	..	..	..	..
Variation..	..	10.0	..	11.0	..	8.3	..	..	..	..

Table 8. Gadus aeglefinus L. 580 mm.
Median line.

No. of scale examined	l_1	d	l_2	d	l_3	d	l_4	d	t_1	t_2	t_3	t_4	Mrg.
1.....	130	—65	280	—52	410	—38	490	—29	130	150	130	80	90
2.....	170	—25	325	—7	460	12	510	—9	170	155	135	50	70
3.....	170	—25	310	—22	440	—8	500	—19	170	140	130	60	80
4.....	200	5	350	18	480	32	520	1	200	150	130	40	60
5.....	190	—5	320	—12	455	7	510	—9	190	130	135	55	70
6.....	190	—5	330	—2	460	12	510	—9	190	140	130	50	70
7.....	195	0	340	8	460	12	520	1	195	145	120	60	60
8.....	175	—20	310	—22	430	—18	495	—24	175	135	120	65	85
9.....	175	—20	295	—37	440	—8	520	1	175	120	145	80	60
10.....	180	—15	310	—22	435	—13	515	—4	180	130	125	80	65
11.....	180	—15	305	—27	435	—13	515	—4	180	125	130	80	65
12.....	180	—15	320	—12	440	—8	520	1	180	140	120	80	60
13.....	190	—5	325	—7	450	2	515	—4	190	135	125	65	65
14.....	190	—5	315	—17	440	—8	510	—9	190	125	125	70	70
15.....	175	—20	310	—22	430	—18	510	—9	175	135	120	80	70
16.....	190	—5	330	—2	450	2	520	1	190	140	120	70	60
17.....	200	5	330	—2	450	2	510	—9	200	130	120	60	70
18.....	195	0	330	—2	445	—3	510	—9	195	135	115	65	70
19.....	200	5	330	—2	440	—8	525	6	200	130	110	85	55
20.....	180	—15	300	—32	425	—23	525	6	180	120	125	100	55
21.....	195	0	310	—22	435	—13	520	1	195	115	125	85	60
22.....	210	15	345	13	450	2	530	11	210	135	105	80	50
23.....	195	0	320	—12	450	2	525	6	195	125	130	75	55
24.....	200	5	330	—2	450	2	520	1	200	130	120	70	60
25.....	205	10	345	13	450	2	520	1	205	140	105	70	60
26.....	210	15	345	13	450	2	530	11	210	135	105	80	50
27.....	220	25	350	18	450	2	525	6	220	130	100	75	55
28.....	220	25	340	8	445	—3	520	1	220	120	105	75	60
29.....	220	25	345	13	455	7	530	11	220	125	110	75	50
30.....	200	5	330	2	440	—8	530	11	200	130	110	90	50
31.....	220	25	350	18	460	12	530	11	220	130	110	70	50
32.....	210	15	355	23	450	2	530	11	210	145	95	80	50
33.....	220	25	390	58	470	22	530	11	220	170	80	60	50
34.....	210	15	370	38	460	12	530	11	210	160	90	70	50
35.....	210	15	360	28	475	27	520	1	210	150	115	45	60
36.....	215	20	355	23	460	12	520	1	215	140	105	60	60
37.....	195	0	325	—7	440	—11	520	1	195	130	115	80	60
38.....	200	5	350	18	460	12	530	11	200	150	110	70	50
39.....	210	15	340	8	440	—8	520	1	210	130	100	80	60
40.....	200	5	340	8	445	—3	520	1	200	140	105	75	60
41.....	210	15	360	28	480	32	530	11	210	150	120	50	50
42.....	170	—25	335	3	440	—8	520	1	170	165	105	80	60
Mean:													
Length ...	195	..	332	..	448	..	519	..	..	..	..	..	..
Variation..	..	13.8	..	14.3	..	10.7	..	7.1	..	..	..	..	..

Table 9. Salmo salar L. 320 mm. Bygland.

	Mean length in mm.			Mean variation in mm.		
	F_1	F_3	F_5	F_1	F_3	F_5
l_1	91	82	77	2.9	4.1	4.2
l_2	178	177	158	7.0	8.1	8.0
l_3	269	265	259	4.1	5.6	4.0
Mrg.	51	55	61	Total variation 14.0	17.8	16.2
	F_2	F_4	F_6	F_2	F_4	F_6
l_1	101	80	79	2.5	4.4	4.7
l_2	190	176	165	5.9	5.7	10.8
l_3	275	257	265	3.5	5.6	8.2
Mrg.	45	63	56	Total variation 11.9	15.7	23.7

Table 10. Salmo salar L. 980 mm. Bornholm.

	Mean length in mm.			Mean variation in mm.		
	F_1	F_3	F_5	F_1	F_3	F_5
l_1	53	37	28	3.2	4.2	6.9
l_2	129	97	91	6.4	4.3	9.1
l_3	437	392	378	10.0	16.7	20.5
l_4	782	758	725	9.7	19.2	16.6
Mrg.	198	222	255	Total variation 29.3	44.4	53.1
	F_2	F_4	F_6	F_2	F_4	F_6
l_1	56	26	17	5.2	6.5	14.7
l_2	131	80	87	7.2	6.8	11.4
l_3	443	390	394	9.1	15.5	31.2
l_4	782	753	740	9.5	12.7	14.3
Mrg.	198	227	240	Total variation 31.0	41.5	71.6

Table 11. Salmo fario L. 235 mm. Åmli.

	Mean length in mm.			Mean variation in mm.		
	F_1	F_3	F_5	F_1	F_3	F_5
l_1	41	36	27	1.9	3.2	8.9
l_2	87	84	82	3.2	4.7	4.1
l_3	146	143	148	4.7	5.3	11.4
l_4	205	204	203	2.7	3.7	4.0
Mrg.	30	31	32	Total variation 12.5	16.9	28.4
	F_2	F_4	F_6	F_2	F_4	F_6
l_1	45	31	38	2.7	4.7	4.1
l_2	93	76	92	1.6	5.8	3.8
l_3	147	133	156	3.3	4.9	5.3
l_4	207	193	210	2.7	4.4	3.2
Mrg.	28	42	25	Total variation 10.3	19.8	16.4

Table 12. Gadus callarias L. 660 mm.

	Mean length in mm.				Mean variation in mm.		
	F_1	F_3	F_5		F_1	F_3	F_5
l_1	139	121	115		6.0	5.5	13.5
l_2	212	205	215		12.5	8.9	28.4
l_3	412	409	422		13.0	9.4	14.3
l_4	601	596	610		3.3	8.3	7.8
Mrg.	59	64	50	Total variation	34.8	32.1	64.0
	F_2	F_4	F_6		F_2	F_4	F_6
l_1	145	121	112		5.9	7.6	7.5
l_2	225	203	194		11.8	10.9	11.2
l_3	419	405	400		11.9	14.7	13.5
l_4	600	598	602		7.3	9.9	12.6
Mrg.	60	62	58	Total variation	36.9	43.1	44.8

Table 13. Gadus callarias L. 460 mm.

	Mean length in mm.				Mean variation in mm.		
	F_1	F_3	F_5		F_1	F_3	F_5
l_1	147	138	119		4.0	5.3	3.3
l_2	304	300	292		3.8	9.0	6.7
l_3	440	433	427		4.2	4.5	2.7
Mrg.	20	27	33	Total variation	12.0	18.8	12.7
	F_2	F_4	F_6		F_2	F_4	F_6
l_1	159	130	112		5.0	7.4	8.0
l_2	313	294	280		7.8	11.2	17.0
l_3	445	435	426		4.2	2.6	4.6
Mrg.	15	25	34	Total variation	17.0	21.2	29.6

Table 14. Gadus virens L. 500 mm.

	Mean length in mm.				Mean variation in mm.		
	F_1	F_3	F_5		F_1	F_3	F_5
l_1	173	165	163		8.1	7.8	9.1
l_2	297	283	279		5.5	7.6	12.2
l_3	400	387	380		5.9	8.8	7.6
Mrg.	100	113	120	Total variation	19.5	24.2	28.9
	F_2	F_4	F_6		F_2	F_4	F_6
l_1	180	164	165		7.8	7.6	12.4
l_2	303	284	288		9.5	9.5	17.8
l_3	399	398	400		9.0	8.6	10.7
Mrg.	101	102	100	Total variation	26.3	25.7	40.9

Table 15. Gadus pollachius L. 600 mm.

	Mean length in mm.				Mean variation in mm.		
	F_1	F_3	F_5		F_1	F_3	F_5
l_1	198	174	175		12.5	11.7	11.6
l_2	424	398	402		9.6	10.3	10.6
l_3	514	486	487		9.6	7.7	10.8
Mrg.	86	114	113	Total variation	31.7	29.7	33.0
	F_2	F_4	F_6		F_2	F_4	F_6
l_1	189	171	150		9.7	9.8	12.8
l_2	409	386	366		12.8	12.6	18.2
l_3	500	474	466		7.5	10.0	12.1
Mrg.	100	126	134	Total variation	30.0	32.4	43.1

Table 16. Gadus aeglefinus L. 580 mm.

	Mean length in mm.				Mean variation in mm.		
	F_1	F_3	F_5		F_1	F_3	F_5
l_1	209	186	170		10.6	9.9	10.0
l_2	349	326	313		15.7	11.6	11.5
l_3	465	449	442		12.2	8.3	10.9
l_4	533	518	513		7.2	7.4	6.9
Mrg.	47	62	67	Total variation	45.7	37.2	39.3
	F_2	F_4	F_6		F_2	F_4	F_6
l_1	207	190	173		13.8	11.5	11.9
l_2	338	339	309		14.1	14.6	13.9
l_3	450	462	449		9.2	13.7	10.8
l_4	527	524	510		5.2	9.4	7.6
Mrg.	53	56	70	Total variation	42.3	49.2	44.2

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Morphometrical Features of the Sea-Trout of Polish Rivers.

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A statistical comparison has been made of the variations of two different races of sea-trout established by us for the river Reda, the large race from the river Dunajec, and the small 4 year old *Salmo salar* ("mielnica") caught every year along the shores of the Gulf of Danzig.

The material for these comparisons was obtained from our investigations on the biology and morphology of the *S. trutta*, conducted on the rivers Dunajec and Reda.

In the years 1923 and 1924, while carrying out the artificial propagation of Salmonidae on the river Dunajec (an upper tributary of the Vistula) and having at our disposal abundant material, we were able to establish the fact that, contrary to the opinions expressed in the Polish ichthyological literature, *S. salar* is not to be found in this river and that this form is replaced in the Dunajec by a local race of sea-trout. The results of these investigations have been given in a report by myself and Dr. Lubecki, issued by the Department of Agriculture in 1926. (Compte rendu de campagne de pêche aux saumons réproducteurs en 1923 et 1924. Warsaw 1926. Edition of the Ministry of Agriculture. Serja D. N. 22.)

The race in the river Dunajec described by us belongs to the group which enters the Vistula with undeveloped gonads a year before spawning; this takes place during October and November in the upper parts of the Dunajec between the towns of Nowy Targ and Nowy Sacz. This race differs from the sea-trout of smaller rivers by its larger size and

weight. It is generally fished during the spawning migration in the Vistula and Dunajec, but is not taken in the sea-fishery in the Polish Baltic, which consists exclusively of *S. salar*.

Continuing the investigations our attention was drawn to the river Reda, which flows into the northern part of Danzig bay ("Putziger Wieck"), noted by Dr. Seligo as the spawning ground of *S. salar*. Our investigations conducted in the years 1928 and 1930 likewise shewed the absence of *S. salar* in that river, as the boundary of the extension of this species in Danzig Bay is the shallow water, called in the German maps "Moven Riff".

The examination of the material collected on the river Reda convinced us that there are two peculiar races of *S. trutta* inhabiting that river. The results of these investigations will be given in a special paper in "The Memorials of Pulava Institute".

On the river Reda we distinguished two peculiar races; the "black" race, called by the local fishermen "black salmon", and the "silver" race.

The "black" race is the form that runs up the Reda, as its mother river, for spawning, which takes place in October, November and the beginning of December. Representatives of this race may be found in the river Reda as early as June, that is, 3 months before spawning.

The "silver" race, which does not spawn in the Reda, begins its migration at the time when the "black" race spawns in November and is to be found there till May. Between the ages of 3 to 6 years the representatives of this race with their gonads undeveloped journey to the Reda for feeding.

The fact of that race feeding in the river, as stated by us, as well as the small development of the gonads in the period of spawning, the presence of the 3 year old fish in that river, and the peculiar morphometrical features all indicate that the "silver" race is only a temporary visitor to the Reda, travelling from Puck Bay to the lower parts of the river, and back.

The difference between the size of the 4—5 year old fish of the Dunajec race and that of the races of the Reda is shewn by comparing the over-all body length (in centimetres):—

Average length			Greatest length			Smallest length		
Dunajec	Reda Black	Reda Silver	Dunajec	Reda Black	Reda Silver	Dunajec	Reda Black	Reda Silver
80.5	57.2	57.3	105	84	82	67	34	38

The fourth object of investigation dealt with in this paper is the small *S. salar* (called "mielnica"), the fishery for which takes place near the shores of Danzig Bay in the early spring. The characteristic feature of "mielnica" is that the stock consists exclusively of fish of the same age, i.e. of 4 year old fish which have had 3 years of river life, the males predominating. One can say that all "mielnica" examined by us appear to conform to one standard, their weight being 300—500 g. and their length 37—45 cm. with no great range and within the limits of length peculiar to the Reda and Dunajec sea-trout.

The material for comparison is as follows:—

1) The biometrical analysis, according to Smitt's scheme, of 25 specimens of sea-trout (Reda).
2) The over-all body lengths of 80 specimens of sea-trout (Reda).
3) The scales for age-determination of 119 specimens of sea-trout (Reda).
4) The weights of 45 specimens of sea-trout (Reda).
5) The biometrical analysis according to Smitt's method of 28 specimens of sea-trout from the Dunajec sent us by Dr. Fr. Lubecki, and 15 specimens of small (36—50 cm.), 4 year old *S. salar.*

In working out the statistical material we made use of the following calculated quantities 1) mean (M), 2) standard deviation (σ) and 3) mean error.

On the basis of these quantities we define the mean error of the difference (m) Dif. $= \sqrt{m_1^2 + m_2^2}$ and give the relation between $(M_1 — M_2)$ and the above-mentioned mean error of the difference $\left(\sqrt{m_1^2 + m_2^2}\right)$.

This relation may be called the index of certainty of the difference between means $(M_1 — M_2)$, as on the basis of Gauss's law of error two means will belong to two separate classes, only when the difference between $M_1 — M_2$ is three times greater than the mean error of the difference, i. e. $\dfrac{M_1 — M_2}{\sqrt{m_1^2 + m_2^2}} > 3$.

Detailed data confirming the presence in the river Reda of two different biological races of sea-trout are given by us in a special paper published in the "Memorials of Pulava Institute". At present our statements are confined to the results of comparison of morphometrical features which gave real differences when comparing the Reda sea-trout with salmon, as well as among themselves.

In order to give a full orientation of the results of measurements we give below a comparison of the means (M), expressed in percentages, respecting the over-all length of the body.

Measurements, after Smitt.

	S. salar	S. trutta		
		(Dunajec)	(Reda) black race	(Reda) silver race
1. Longitudo capitis totalis	19.0	19.9	19.9	18.7
2. — mediae partis capitis	12.1	12.7	14.8	13.8
3. Spatium praeorbitale	5.7	6.5	6.6	5.4
4. Longitudo mandibulae superioris	6.4	7.3	7.6	7.2
5. — maxilae inferioris	11.4	12.2	12.2	11.5
6. Spatium praedorsale	39.0	41.5	40.5	40.3
7. Longitudo pinnae dorsalis	10.6	10.2	11.2	10.5
8. Altitudo pinnae dorsalis	10.4	10.1	12.3	11.8
9. Longitudo pinnae pectoralis	12.5	12.0	13.2	12.4
10. — anterioris partis ventralis	28.9	29.5	28.2	28.8
11. — praeventrale	45.7	48.5	47.7	46.8
12. Altitudo pinnae ventralis	11.1	9.8	11.0	10.7
13. Spatium postventrale	21.9	21.5	22.0	21.8
14. Longitudo pinnae analis	7.7	8.1	8.5	8.3
15. Altitudo pinnae analis	8.6	10.5	12.5	12.2
16. Longitudo dorsalis pedunculi caudae	13.3	11.4	8.7	10.6
17. — lateralis pedunculi caudae	20.5	17.7	16.8	17.6
18. — ventralis pedunculi caudae	16.4	12.0	10.8	13.3
19. Altitudo minima corporis	6.3	7.6	8.2	7.8

Only a superficial comparision of the above data tells us how essential is the difference between the series of morphometrical features of the small *S. salar* and the races of the sea-trout, as well as that of the sea-trout among themselves.

Let us analyse the difference between *S. salar* and *S. trutta* of the Reda river and then of the races of *S. trutta* of the Dunajec and Reda rivers.

Features	Species	M	σ	m	Fluctuations of means	$\frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}}$
Altitudo pinnae dorsalis	Sea-trout, silver race	11.8	0.83	0.24	10.4-13.1	$\frac{11.8 - 10.4}{\sqrt{0.24^2 + 0.20^2}} = 4.6 > 3$
	S. salar	10.4	0.7	0.2	9.4-11.8	
Altitudo pinnae analis	Sea-trout, silver race	12.2	0.67	0.19	10.5-13.1	$\frac{12.2 - 8.6}{\sqrt{0.19^2 + 0.22^2}} = 12.8 > 3$
	S. salar	8.6	0.78	0.22	7.3-9.9	
Longitudo dorsalis pedunculi caudae	Sea-trout, silver race	10.6	1.1	0.31	8.7-12.4	$\frac{13.3 - 10.6}{\sqrt{0.35^2 + 0.31^2}} = 6 > 3$
	S. salar	13.3	1.21	0.35	10.6-14.3	
Longitudo ventralis pedunculi caudae	Sea-trout, silver race	13.3	0.68	0.19	12.1-14.5	$\frac{16.4 - 13.6}{\sqrt{0.27^2 + 0.19^2}} = 9.4 > 3$
	S. salar	16.4	0.95	0.27	14.5-17.0	
Longitudo lateralis pedunculi caudae	Sea-trout, silver race	17.6	0.69	0.20	16.2-18.6	$\frac{20.5 - 17.6}{\sqrt{0.24^2 + 0.20^2}} = 9.6 > 3$
	S. salar	20.5	0.86	0.24	19.6-22.2	
Altitudo minima corporis	Sea-trout, silver race	8.2	0.58	0.16	7.1-8.3	$\frac{8.2 - 6.3}{\sqrt{0.16^2 + 0.18^2}} = 7.9 > 3$
	S. salar	6.3	0.56	0.18	5.7-7.3	

Comparison of the means of the *pedunculi caudae* shews that the side of the *pedunculi caudae* as well the edges of the dorsal and ventral fins of *Salmo salar* are considerably longer than those of the "silver" trout, but the *altitudo minima corporis* of the *S. salar* is considerably less.

The extent of the difference of the morphometrical features of the *pinnae caudalis* of the species compared can be seen from the fact that the difference between these features are twice, or even more than three times, the difference which is considered to be real according to the law of statistics. Comparison of the *altitudo pinnae dorsalis*, as well as the *p. analis* also gives a considerable difference; the height of the "silver" sea-trout's fins is considerably greater. One must note the special difference between the lengths of the anal fin.

The comparison of the *Salmo salar* with the "black" sea-trout gives the following results:—

Features	Species	M	σ	m	Fluctuations of means	$\frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}}$
Altitudo pinnae dorsalis	Sea-trout, black race	12.3	1.0	0.27	10.5-13.8	$\frac{12.3 - 10.4}{\sqrt{0.27^2 + 0.20^2}} = 5.7 > 3$
	S. salar	10.4	0.7	0.20	9.4-11.8	
Altitudo pinnae analis	Sea-trout, black race	12.5	0.06	0.02	11.8-13.6	$\frac{12.5 - 8.6}{\sqrt{0.02^2 + 0.22^2}} = 17.3 > 3$
	S. salar	8.6	0.78	0.22	7.3-9.9	
Longitudo dorsalis pedunculi caudae	Sea-trout, black race	13.3	1.21	0.35	10.6-14.3	$\frac{13.3 - 8.7}{\sqrt{0.35^2 + 0.37^2}} = 12.1 > 3$
	S. salar	8.7	1.18	0.37	7.0-11.3	
Longitudo ventralis pedunculi caudae	Sea-trout, black race	16.4	0.95	0.27	14.5-17.8	$\frac{16.4 - 10.8}{\sqrt{0.27^2 + 0.5^2}} = 10.8 > 3$
	S. salar	10.8	1.8	0.5	8.2-14.2	
Longitudo lateralis pedunculi caudae	Sea-trout, black race	20.5	0.87	0.25	19.6-22.2	$\frac{20.5 - 16.8}{\sqrt{0.25^2 + 0.38^2}} = 8.4 > 3$
	S. salar	16.8	1.4	0.38	13.5-18.4	
Altitudo minima pedunculi caudae	Sea-trout, black race	8.2	1.2	0.33	7.1-8.8	$\frac{8.2 - 6.3}{\sqrt{0.33^2 + 0.18^2}} = 5.1 > 3$
	S. salar	6.3	0.56	0.18	5.7-7.3	
Longitudo mandibulae superioris	Sea-trout, black race	7.6	0.81	0.22	6.8-9.4	$\frac{7.6 - 6.4}{\sqrt{0.22^2 + 0.28^2}} = 3.5 > 3$
	S. salar	6.4	0.86	0.28	5.8-6.9	
Spatium praeventrale	Sea-trout, black race	47.7	1.5	0.41	46.2-50.7	$\frac{47.7 - 45.7}{\sqrt{0.41^2 + 0.43^2}} = 3.4 > 3$
	S. salar	45.7	1.5	0.43	42.9-47.4	

From these comparisons it results that, as regards the morphometrical features, the black race of Reda sea-trout is still farther from *Salmo salar* than the silver one, as is seen in the following comparison of the differences between M_1 and M_2.

	Sea trout (silver race)	Sea trout (black race)
Altitudo pinnae dorsalis	—4.6	—5.7
— — ventralis	—12.8	17.3
Longitudo dorsalis pedunculi caudae	—6.0	—12.1
— ventralis pedunculi caudae	—9.4	8.8
— lateralis pedunculi caudae	—9.6	8.4
Altitudo minima corporis	—7.1	5.1
Longitudo mandibulae superioris		3.5
Spatium praeventrale		3.4

Thus *p. dorsalis* and *ânalis* of the sea-trout of the black race are still longer than those of *S. salar*. The *pedunculi caudae*, as in the silver race, are shorter than in *Salmo salar*; the minimum height of body is greater. We found, too, real differences between M_1—M_2 with the black race for *mandibulae superior* and *spatium praeventrale*, which is also longer than with *Salmo salar*.

The *mandibula superior* of the silver race is nearly as long as that of *S. salar* and, when comparing the class frequency, one obtained an unreal difference, i.e. 2.6; but with the black race it is much longer and reaches distinctly beyond the hinder edge of the eye. Separate figures of the morphometrical elements of body mentioned as well as the results of comparison of class frequency, prove that the silver race of sea-trout of the Reda, which possesses morphometrical and anatomical features (quantity of *appendices pyloryci*) proper to sea-trout, occupies in a morphometrical respect a position between the black race and *Salmo salar*, being near the latter according to their morphometrical features.

Let us pass to the morphometrical analysis of the races of *Salmo trutta* of the Reda, the comparative material for which is given in the table below:—

Features	Species	M	σ	m	Fluctuations of means	$\frac{M_1 - M_2}{\sqrt{m_1^2 + m_1^2}}$
Longitudo capitis totalis	Silver race	18.7	0.86	0.24	17.0-23.0	$\frac{19.9 - 18.7}{\sqrt{0.24^2 + 0.27^2}} = 3.3 > 3$
	black race	19.9	1.0	0.27	18.7-22.8	
Spatium preaorbitale	Silver race	6.6	0.9	0.25	5.6-8.9	$\frac{6.6 - 5.4}{\sqrt{0.25^2 + 0.17^2}} = 4 > 3$
	black race	5.4	0.62	0.17	4.3-6.6	
Longitudo ventralis pedunculi caudae	Silver race	13.3	0.68	0.19	12.1-14.5	$\frac{13.3 - 10.8}{\sqrt{0.19^2 + 0.5^2}} = 4.8 > 3$
	black race	10.8	1.8	0.50	8.2-14.2	
Longitudo dorsalis pedunculi caudae	Silver race	10.6	1.1	0.31	12.1-14.5	$\frac{10.6 - 8.7}{\sqrt{0.31^2 + 0.37^2}} = 5.2 > 3$
	black race	8.7	1.18	0.37	7.0-11.3	

Thus, as regards the head and the *dorsalis pedunculi caudae*, we succeeded in establishing real differences which confirm the opinion that the special biological silver race of sea-trout (not spawning in the Reda)

is accompanied by definite morphometrical features. The black race (spawning in the Reda) possesses a longer head and a longer *spatium praeorbitale*. The comparison of the fins shews that the *pedunculum caudae* of the silver race is longer that of the black one.

Let us pass to the morphometrical analysis of the sea-trout of the Dunajec, comparing them with the races of the sea-trout of the Reda, first with the black and then with the silver race.

Features	Species	M	σ	m	Fluctuations of means	$\frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}}$
Longitudo capitis med.	Dunajec	12.7	0.8	0.5	12.2-15.4	$\frac{14.8 - 12.7}{\sqrt{0.5^2 + 0.33^2}} = 3.5 > 3$
	black race	14.8	1.38	0.33	12.4-16.7	
Altitudo pinnae dorsalis	Dunajec	10.1	0.8	0.15	8.2-11.9	$\frac{12.3 - 10.1}{\sqrt{0.15^2 + 0.27^2}} = 7.3 > 3$
	black race	12.3	1.0	0.27	10.5-13.8	
Longitudo pinnae pectoralis	Dunajec	12.0	0.51	0.1	11.1-13.1	$\frac{13.1 - 12.0}{\sqrt{0.1^2 + 0.2^2}} = 5 > 3$
	black race	13.1	0.75	0.2	12.1-14.7	
Longitudo anterious partis ventralis	Dunajec	29.5	1.46	0.27	26.5-32.5	$\frac{29.5 - 28.2}{\sqrt{0.27^2 + 0.24^2}} = 3.6 > 3$
	black race	20.2	0.89	0.24	26.3-29.3	
Altitudo pinnae ventralis	Dunajec	9.8	0.51	0.09	8.5-19.6	$\frac{11.0 - 9.8}{\sqrt{0.09^2 + 0.19^2}} = 6 > 3$
	black race	11.0	0.71	0.19	9.6-12.3	
Altitudo pinnae analis	Dunajec	10.5	0.65	0.12	9.5-11.7	$\frac{12.5 - 10.5}{\sqrt{0.12^2 + 0.02^2}} = 9 > 3$
	black race	12.5	0.06	0.02	11.8-13.6	
Longitudo dorsalis pedunculi caudae	Dunajec	11.4	0.67	0.31	10.2-12.7	$\frac{11.4 - 8.7}{\sqrt{0.31^2 + 0.37^2}} = 5.5 > 3$
	black race	10.8	1.8	0.50	8.2-14.2	

Summarizing the results of the above comparisons we come to the conclusion that, in relation to the black sea-trout of the Reda, the Dunajec fish has 7 special morphometrical features, namely:—

1) shorter middle part of the head,
2) shorter fins, *dorsalis*, *lateralis*, *ventralis* and *analis*,
3) longer front part of stomach,
4) longer *dors. pedunculi caudae*

The comparison with the silver race gives the following results:—

Features	Species	M	σ	m	Fluctuations of means	$\frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}}$
Longitudo capitis totalis	Dunajec	19.9	0.59	0.11	18.9-21.5	$\frac{19.9 - 18.7}{\sqrt{0.11^2 + 0.24^2}} = 5 > 3$
	silver race	18.7	0.86	0.24	17.0-20.3	
Longitudo ventralis pedunculi caudae	Dunajec	12.0	1.01	0.2	10.1-14.2	$\frac{13.3 - 12.0}{\sqrt{0.2^2 + 0.19^2}} = 5 > 3$
	silver race	13.3	0.68	0.19	12.1-14.5	
Altitudo pinnae dorsalis	Dunajec	10.1	0.8	0.15	8.2-11.9	$\frac{11.8 - 10.1}{\sqrt{0.15^2 + 0.24^2}} = 6 > 3$
	silver race	11.8	0.83	0.24	10.4-13.1	
Longitudo pinnae ventralis	Dunajec	9.8	0.51	0.09	8.5-10.6	$\frac{10.7 - 9.8}{\sqrt{0.09^2 + 0.21^2}} = 4.1 > 3$
	silver race	10.7	0.75	0.21	9.2-11.9	
Spatium praeventrale	Dunajec	48.5	1.31	0.24	45.1-52.1	$\frac{48.5 - 46.8}{\sqrt{0.24^2 + 0.37^2}} = 3.9 > 3$
	silver race	46.8	1.3	0.37	44.0-49.2	
Altitudo pinnae analis	Dunajec	10.5	0.65	0.12	9.5-11.7	$\frac{12.2 - 10.5}{\sqrt{0.12^2 + 0.19^2}} = 7.7 > 3$
	silver race	12.2	0.67	0.19	0.5-13.1	

Hence the sea-trout of the Dunajec possess the following morphometrical features which distinguish them from the silver sea-trout of the Reda:—

1) longer head,
2) shorter middle part of head,
3) shorter fins, *dorsalis*, *ventralis*, *analis*,
4) longer front part of stomach,
5) longer *spatium praeventrale*,
6) longer *ventr. ped. caudae*.

The above results of statistical comparisons as well as the earlier data at our disposal enables us to state that in the fauna of Polish rivers *Salmo trutta* is represented by 3 local races — "silver" and "black" in the Reda, and the Dunajec, wandering by way of the Vistula to the upper Dunajec.

The question of the presence of sea-trout in other tributaries of the Vistula, as for instance in Brda, where a few examples of *S. salar* are taken at the spawning time, is not yet solved, as for the time being no specimens of sea-trout have reached the investigators hands.

Reviews.

MARVIN WILLIAMS. Horizontal and Upward Intensity of Light in Puget Sound Waters. Publ. Puget Sound Biol. Station. Vol. 7, pp. 129—135. Washington 1929.

Gas-filled potassium photo-electric cells were used, the sensitized surface being hemispherical. No diffusing surface was used. The current was measured with either a micro-ammeter on a "power boat" or with a delicate galvonometer on shore. Measurements were made on calm days with fairly constant lighting conditions, down to a depth of six metres. It was found that the rate of decrease in intensity of diffused light per metre was constant. It was concluded that the relative amounts of light energy received by an object on the sides and bottom in relation to that received on the top increases as the depth increases, that on the bottom increasing faster than that on the sides. There is a tendency for the horizontal intensity in different directions to become equal as the depth increases.

It is of interest to compare these results with those obtained by POOLE and ATKINS (1928) in the English Channel. They found that the reading with photometer window vertical averaged about 0.14 of the reading at the same depth with window horizontal. W. R. G. A.

V. E. SHELFORD. The Penetration of Light into Puget Sound Waters as measured with Gas Filled Photoelectric Cells and Ray Filters. Publ. Puget Sound Biol. Station. Vol. 7, pp. 151—168. Washington 1929.

After a discussion of the errors inherent in the use of gas-filled cells it was concluded that satisfactory results could none the less be obtained with them. The cells were of sodium, potassium (two), rubidium and caesium and were used unscreened or with appropriate colour filters. With sodium a 3 mm. screen of Corning "ultra" glass was used to obtain a maximum sensitivity at 3650 Å. U. A blue glass was used with the potassium cells, a green with rubidium and a yellow with caesium. With the latter a red glass also was used, but the sensitivity of caesium to red is very small. Measurements were made on ten days, nine cloudless, one uniformly overcast during July and August. Fig. 1 shows the percentage of light transmitted in Puget Sound waters, using the cells without light filters. The minimum transmission occurred at different depths with different photometers, but the measurements were not made on the same

day. Fig. 2 compares the 1920 with the 1926 readings, those for the former indicating much clearer water. Fig. 3 shows the results obtained with the colour filters. The caesium cell with red filter could only be read to 6 m., with yellow filter to 8 m. The other cells were used to 25 or 50 m. The greatest obstruction to the red and yellow light was found to be within the first three metres, to the green in the fourth, to the blue and violet in the seventh metre. The rapid clearing of the water to the violet light below 8 m. is striking. These readings were not on the same date in every case but the same tendency was shown for all the dates in each colour. The reviewer suggests that these peculiar results may be due to the fact that the filters allow light to pass over a considerable spectral range. After, for example, heavy absorption of the red in passing the upper three metres, the residual light approximates to yellow and so is transmitted more freely. Poole and Poole (1930) suggest this as the explanation of their results with a sodium cell in Lough Bray.

W. R. G. A.

R. de Buen. Resultados obtenidos en las campañas del "Xauen" por el estrecho de Gibraltar en 1929. Instituto Español de Oceanografía, Notas y Resúmenes, Ser. II, No. 39. Madrid, 1930.

This paper, which includes a summary in French, deals with three hydrographic sections worked in September and two worked in December 1929 by the Spanish Institute of Oceanography. The cruises were planned in conjunction with the International Commission for the Exploration of the Mediterranean and the International Council for the Exploration of the Sea.

The sections Punta Almina — Punta Carnero and Cape Trafalgar — Cape Espartel indicate an upper layer of Atlantic water overlying water of Mediterranean character, the boundary lying deeper in December on the line Cape Trafalgar — Cape Espartel.

On the line Cadiz—Larache water of Mediterranean origin, having a salinity greater than 37 grams per kilo, was met with in December below a depth of 300 metres. In September depths below 225 metres were not worked on this route. Further work in the area is projected. H.W. H.

Johs. Schmidt. Introduction to the Oceanographical Reports. The Danish "Dana"-Expeditions 1920—1922. No. 1. Copenhagen, 1929.

The three expeditions of which Dr. Schmidt here gives an account are the sequel to the researches in the North Atlantic begun by the "Thor" and "Margrethe" early in the present century and continued until the war intervened. As soon as events allowed, the promise of the "Margrethe's" work on the now famous study of the European eel was taken up, and a Committee was formed under the patronage of H.R.H. Prince Valdemar of Denmark, with the object of organising further expeditions to the Sargasso Sea. Specially mentioned in this connection are the great efforts made by the late Commodore C. F. Drechsel, R. Dan. N., in raising the funds necessary for this purpose.

The first two post-war expeditions were made in the "Dana" I, a four masted auxiliary schooner, which had been placed at the disposal of the Committee by the Danish East Asiatic Company of Copenhagen. The first, under the leadership of Dr. SCHMIDT, began from Gibraltar and finished at Copenhagen, covering the period March to September 1920. In the following year (1921), between February and May, Captain HANSEN, the commander of the vessel, directed a cruise in the Sargasso Sea, starting from, and returning to, the West Indies. On these two voyages the work was largely restricted to the study of pelagic and bathy-pelagic organisms, mainly owing to the unsuitability of the ship for other kinds of work.

In the meantime, the Danish Government had acquired a steam-trawler of the Lord Mersey class, which was adapted for marine research. In this ship, the Royal Danish Research Ship "Dana", Dr. SCHMIDT undertook the third and most extensive cruise, which started from Copenhagen in August 1921 and ended at the same place nearly a year later (July 1922). The penetration of the Mediterranean and Pacific on that occasion foreshadowed the even more ambitious voyage from which, news comes, the little vessel is now returning.

The details of the ship and the equipment are fully described and illustrated. The chief difference, Dr. SCHMIDT remarks, between the earlier methods and those employed in "Dana" II, is the use of nets and water-bottles in series on the one wire, which not only saves time, but tends to greater accuracy, especially in hydrographic observations. The work done is briefly outlined, and one may mention, *inter alia*, the hydrographic sections across the Equatorial Current and the Gulf Stream, the demonstration of a seasonal periodicity in the biological phenomena of the Sargasso and Caribbean Seas, and the further progress made in the study of the development of the European eel and other muraenoids, of which a number of eggs and the youngest larval stages were obtained. Various opportunities, namely, in the Gatun Lake and while sheltering from bad weather off Beata Island, were taken for botanical work ashore, under Professor OSTENFELD.

The paper is completed with a detailed list of stations of the three expeditions, a table of the hydrographic observations made on the third voyage ("Dana" II), and a number of charts shewing the itineraries and stations. J. R. L.

GEORG WÜST. Der Golfstrom. Zeitschrift der Gesellschaft für Erdkunde zu Berlin, 1930, No. 1/2, pp. 42—59.

This paper presents in concise form a review of the latest knowledge of the oceanographic features of the Gulf Stream proper, that is, of the current as far as the Great Bank of Newfoundland. Making use of the most recent observations, the author amplifies his previous study (Florida- und Antillenstrom. Veröff. Inst. für Meereskunde, 1924) in which dynamical methods were successfully employed in correlating and interpreting the observations made at various times in the Gulf Stream.

After a brief historical notice, in which the importance of HUMBOLDT's

contribution is stressed, the author considers first the surface features of the Gulf Stream and then the subsurface features. For the surface of the Gulf Stream there is a relatively large mass of observational material; for the subsurface, however, there are but few observations. This makes the application of dynamical considerations of the very first importance: for it is only by such means that the scattered observations can be combined to give a correct understanding of the characteristics of the waters embraced in this great ocean current.

The questions more specially discussed by Wüst relate to the distribution of temperature, salinity and velocity, and to the transport of water and heat. Five sections across the Gulf Stream, drawn to the same scale and covering the region from Yucatan to the Great Bank of Newfoundland, bring out in graphic form the temperature and salinity conditions prevailing. Instead of the still-popular notion of the Gulf Stream as an unusually warm body of highly saline and homogeneous water — a river in the sea — these diagrams bring out clearly the very decided stratification of the water comprising the Gulf Stream, the temperature in the Straits of Florida, for example, ranging from 25° C. at the surface to 10° at a depth of 400 meters. They also bring out the fact that the neighboring water of the Sargasso in the same latitude is warmer and of higher salinity.

The most saline water in the Gulf Stream has a salinity of a little more than $36^1/_2$, and is found, not at the surface, but at a depth of from 100 to 200 meters. This more highly saline layer of water is a characteristic feature in the vertical distribution of salinity in the Gulf Stream and is explained by Wüst as coming from the Sargasso Sea, from which it is carried as a subsurface current into the North Equatorial Current and thence through the Carribean into the Gulf of Mexico.

The vertical velocity distribution is figured for three sections, two based on observations and the third based on computation. By means of these the transport of heat and water on the part of the two components of the Gulf Stream, namely the Florida Current and the Antilles Current, may be computed. Wüst here gives the results as found in his earlier paper in which he showed that, contrary to what had been accepted, the Florida Current was the principal contributor, both in regard to the heat and water. The amount of water discharged by the Florida current is about 24 million cubic meters per second, or as Wüst puts it in striking fashion, about 22 times the total amount of water discharged by all the rivers of the world in a like period of time. In conclusion he directs attention to the fact that the conditions within the Gulf Stream are subject to variations both periodic and nonperiodic, and that one of the most important future problems is the determination of these variations.

H. A. M.

A. Defant. Die Theorie der Meeresströmungen und die ozeanische Zirkulation. Geografiska Annaler, Vol. XI (1929) pp. 268—293.

The problems involved in oceanic circulation are so complex that they do not lend themselves readily to formulation in a general dynamical theory. To cope with this difficulty, it has been necessary to introduce

assumptions of a simplifying nature, the most successful method consisting in the formulation of typical simple problems and their solution by exact analytical methods. The actual problems involved in ocean currents are then attacked, not directly by analytical methods, but by combining suitably the typical simple problems that have been solved.

In the paper under review Dr. DEFANT elucidates the salient features of the dynamical theory of ocean currents as it has been developed to date. The forces that give rise to ocean currents are conveniently divided into two groups, internal and external; that is, forces residing within the sea, and forces residing outside the sea. The first simplification of the actual problem consists in assuming a sea of homogeneous water, which in effect eliminates the internal forces. In the consideration of this, DEFANT summarizes the basic contributions made by V. W. EKMAN and discusses in some detail the pure wind drift and the pure gradient current.

The currents arising from the internal forces are developed most readily from the concept of homogeneous water masses (Wasserkörper), that is, of more or less extended masses of water, each possessing uniform physical and chemical characteristics. DEFANT considers the behavior of such water masses under various conditions and illustrates the theoretical results by examples drawn from observations.

Turning now to the application of the results obtained from the foregoing theoretical discussion to the general question of oceanic circulation, DEFANT directs attention to the striking thermic constitution of the sea — a relatively shallow upper layer of warm water and the cold mass of subsurface waters. These he denominates respectively the "oceanic troposphere" and the "oceanic stratosphere" in analogy to the corresponding stratification in the atmosphere. Since the ultimate cause of ocean currents is to be found in the effects of the atmosphere, it follows that the troposphere is the seat of the primary features in the circulation of the sea. These features, as they relate to the Atlantic Ocean, are discussed in some detail.

In the main, the waters of the troposphere remain in the upper layers of the sea. And if the stratosphere were everywhere covered by the waters of the troposphere, the deeper waters would constitute a motionless mass. In the polar latitudes of both hemispheres, however, the absence of the layer of warm water of the troposphere permits the stratosphere to reach the surface of the sea. Here two different kinds of water are found which give rise to circulation in the stratosphere. The first kind of water has its origin in the precipitation of the polar regions and in the melting of ice. These give rise to water masses of low salinity and relatively low temperature. The second kind of water arises as a result of radiation during the long cold polar night. This water, however, is of normal salinity but of very low temperature. The first kind of water being light remains in the upper layers of the stratosphere and gives rise to the Arctic and Antarctic subsurface currents. The second kind of water, being heavy, sinks to the bottom and gives rise to the cold polar bottom currents.

In conclusion DEFANT directs attention to the fact that in the problem of oceanic circulation we are still dealing with qualitative results and that even these are far from complete. For the deeper layers of the

sea, for example, we have thus far only a very rough outline of the meridional circulation. We know nothing of the zonal currents in the depths; nothing in regard to fluctuations in the strength of the deep-sea currents; and nothing of the relations subsisting between the currents in the three oceans. To quote DEFANT, "In the solution of these problems lies the future of oceanography". H. A. M.

ALBERT DEFANT. Die vertikale Verteilung von Temperatur und Salzgehalt im Weltmeere. Zeitschrift der Gesellschaft für Erdkunde zu Berlin, 1930, No. 1/2, pp. 28—42.

The vertical distribution of temperature and salinity in the sea are oceanographic problems of importance not only in themselves, but also in relation to the larger problem of oceanic circulation. It is with respect to the latter problem that Dr. DEFANT considers these matters in the paper under review. And in this connection he directs attention to the fact that there is a school of thought which still regards the deeper layers of the sea to be completely motionless.

Starting with a consideration of the question of the vertical distribution of temperature in the case of a complete mixing of the waters from top to bottom, the author shows that an adiabatic temperature gradient of small magnitude must exists because of the compressibility of water. For a temperature of 0° C. at the surface, thn temperature at a depth of 10,000 meters should be from this cause 1,2°. The actual temperature distribution in the sea, however, is quite the reverse, the temperature decreasing with depth. Only in the deeper parts of the oceanic deeps are there any indications of the adiabatic temperature gradient.

The consideration of the typical distribution of temperature in the Atlantic Ocean leads DEFANT to characterize the thermic constitution of the sea as consisting of two layers: the troposphere constituting the upper warm layer and the stratosphere constituting the great mass of the cold subsurface waters, these two layers being separated by a discontinuity layer (Sprungschicht) at a depth of from 600 to 800 meters. In the troposphere the curve representing the vertical distribution of temperature is concave upward, while in the stratosphere this curve is concave downward.

Both molecular conduction and dynamic convection tend to bring the waters of the sea into an isothermic condition. Between the depths of 200 and 1000 meters, DEFANT calculates the molecular conduction of heat per day to be at the rate of 0.12 gram calories per square centimeter. The dynamic convection depends on the degree of turbulence, but according to DEFANT is between the depths of 200 and 1000 meters of the order of 50 to 100 gram calories per square centimeter per day. In spite of these relatively large quantities of heat being conducted from the troposphere to the stratosphere, the vertical temperature distribution remains constant. It follows therefore that this distribution is primarily due to the oceanic circulation. It could not be maintained if the lower layers of the ocean were at rest.

Coming now to the question of salinity, the general rule with regard

to the vertical distribution in the sea may be summarized as: Maximum salinity at the surface with a more or less gradual decrease to a minimum at a depth of about 800 meters, followed by an increase to about 2000 meters, beyond which the salinity remains practically constant. The striking feature here is the minimum at the depth of about 800 meters, which is explained as due to the polar intermediate currents.

From a consideration of the salinity gradients, DEFANT calculates a daily transport of 21 milligrams of salt per square centimeter into the 500-meter layer between the depths of 450 and 950 meters. This constant inflow would therefore within a year or two be sufficient to wipe out the salinity minimum at the 800 meter depth, were it not for the existence of currents. The vertical distribution of salinity, like that of temperature, is maintained through the medium of oceanic circulation.

H. A. M.

L. BREITFUSS. Die Erschliessung des Eurasiatischen hohen Nordens. 30 Jahre einiger Arbeit an der wissenschaftlichen und kulturellen Erschliessung des nördlichen Eismeeres, 1898—1928. Petermanns Mitteilungen. Ergänzungsheft Nr. 207. Gotha, 1930.

In 1898 the Committee for the Assistance of the Coastal Population of Northern Russia initiated the Scientific Murman Expedition under the leadership of Professor KNIPOWITSCH with Dr. LEONID BREITFUSS as his assistant. The purpose of the expedition was the development of the fishing and sealing industries and the improvement of the condition of the fishermen. At that time their lot was a hard one. They were largely in the hands of the local traders, though there was a certain amount of barter with Norwegian ships in the harbours. Fishing was carried out chiefly by long lines in open sailing boats. Little was known of the depth and bottom, and the chart was nearly blank even on the fishing grounds. One of the chief objects of the expedition was the improvement of the fishing craft, and a certain number of Norwegian vessels were purchased and either let or sold to the fishermen. A second object was the preparation of charts, and as a preliminary soundings were made along the meridians of the most important fishing stations and bottom specimens were collected. A third was the introduction of improved methods of salting the fish. This was being carried out under most insanitary conditions with badly washed fish, the salt being imported from Liverpool, and the resulting product looked and smelled abominable. Two skilled Dutch curers were introduced and prepared salt fish in the ships of the expedition which was sold in St. Petersburg as a delicacy. Other questions to which attention was directed were telegraphic fishery and ice bulletins, life saving (life boats to accompany the fishing fleet were provided), the opening up of winter communication along the coast by means of steamers, and the foundation of boarding schools.

On the scientific side physical and biological oceanography held a prominent place, and in 1902 regular participation in the quarterly cruises of the International Council for the Exploration of the Sea became a matter of obligation. The economic programme was a large one and made

considerable incursions into the time available for scientific work, but on the other hand the expedition enjoyed a considerable measure of independence, and its comparative failure was due to another cause. Dr. Breitfuss tells us that the Committee was unsuited to the task of directing its operations and expending its money properly. Friction arose almost at once, and in 1901 Professor Knipowitsch resigned his post and was succeeded by Dr. Breitfuss as leader. But the financial difficulties continued and in 1908 the expedition came to an end after an enquiry by the Duma; the author was retained to work up the large amount of material still unpublished, and at the time of the outbreak of war had the reports for the years 1905 and 1906 ready for the press. The soundings were on the charts, but the bottom specimens, a thousand or more, are unexamined to this day.

The paper under review is a guide to the scientific work of the author and therefore to one side of the history of the Expedition. It contains an index chart showing the positions of the open-sea stations to the number of 2000 and the tracks of the chief exploring and relief expeditions, sections on the oceanography and industrial conditions of the region, and a list of 185 papers by the author which should be of considerable value to all interested in the Barents Sea.

Dr. Breitfuss is convinced that we still know far too little of the oceanography of these waters to be able to chart the currents with any approach to accuracy and suggests the following programme for future work. The sea should be surveyed by means of stations 15 miles apart along the meridians of 33°30′ E. and 38° E. which should be worked as nearly simultaneously as possible. A later watch could be kept over the phenomena in the North Cape Current by means of observations made at fixed positions and at fixed intervals of time. A valuable improvement would be stations along a line from Sogne Fjord in Norway to Hornnes in Iceland, which the author believes would make it possible to forecast the conditions even two years ahead. D. J. M.

W. R. G. Atkins. Seasonal changes in the nitrite content of sea-water. Journ. Mar. Biol. Assoc., N. S., vol. XVI, no. 2, pp. 515 et seq. Plymouth, 1930.

The determination of nitrates in the sea is not easy, and two determinations are required to show that they are being produced. The determination of nitrites is relatively simple, and it is known that they are a stage in the oxidation of ammonium salts to nitric acid. Their presence may therefore be looked upon as a sign that nitrates are being produced. It must of course be certain that they are not derived from the land; Dr. Atkins quotes figures to show that the land effect does not often extend even halfway to station E 1, 20 miles off Plymouth, from which most of his results are drawn.

During the autumn, winter and spring of 1928/9 the nitrites at this position changed with the seasons. In August the upper 20 metres were almost free from nitrites, while the lower layers held large quantities, up to 38 mg. per cubic metre. In October they were plentiful at all depths,

and at the end of November only small amounts were found. In the period January to March they increased again.

There are two criticisms which may be suggested with regard to Dr. Atkins' paper. One is that some chemists still hold that nitrites may be formed by the degradation of nitrates. The other is that it may be doubted whether it is altogether allowable to treat variations occuring at any one place over long periods as if they were due to changes occuring there: the water at E1 could move a considerable distance in a month. A more detailed discussion of this point would be welcome. D. J. M.

G. Böhnecke, E. Hentschel und H. Wattenberg. Über die hydrographischen und biologischen Verhältnisse an der Meeresoberfläche zwischen Island und Grönland. Ann. d. Hydr. u. mar. Met., LVIII Jahrg., H. VII. Berlin, 1930.

This is a preliminary account of a cruise in the survey ship "Meteor" in August 1929 in the Denmark Strait and Irminger Sea. This ship is now commissioned every year for fishery supervision work, but as it is fully equipped for oceanographic work, it is only natural that advantage is taken of its presence in waters where interesting observations are to be expected, — as in the area chosen where the meeting of Atlantic and polar water gives rise to a well-defined polar front. The article under review deals almost exclusively with the surface conditions, reserving the sub-surface observations for treatment in connection with those from the second year of the investigation planned (1930). The scope of the work covers similar investigations as on the S. Atlantic expedition, and in addition further chemical properties of the sea water were determined (ammonia, nitrates, plankton-poisons), the workers (and authors of the article) being mostly those who so successfully carried through the 2 years work which has made the "Meteor" famous.

The surface observations show very clearly the complicated nature of the water movements in this polar front area, — much more complicated than was anticipated by earlier oceanographers. Along the "front", which runs roughly in a direction E by N to W by S, the existence of four stationary cyclonic whorls was demonstrated, each characterised by a central area of maximal density.

As to phosphates and nitrates, which everywhere showed the familiar increase with depth for the first 100 m or so, the surface quantities were greatest in the SW corner of the area, probably owing to a more thorough mixing of the two main water masses. The Greenland coastal water showed conspicuously low values, in direct opposition to the view recently held by some workers (that the water resulting from mixture of snow and ice was the main source of the nutrient salts). It may be mentioned that Wattenberg here introduces a new way of denoting the phosphate content of the water, namely, as mg of P instead of P_2O_5 per cub/m, which seems rational and practical, and might be adopted by other observers. (Values given in the old way may be converted by dividing by 4.6).

The ammonia content was found to run directly opposite to the nitrate content, with increasing depth, thus supporting Harvey's finding, that

nitrification goes on in the depths. Another of HARVEY's conclusions is also upheld by WATTENBERG's work, namely, that the plankton life of the upper layers produces "poisons", which tend to limit further growth. The effect of such "poisons" was studied by a purely chemical method devised by HARVEY (rate of decomposition of hydrogen peroxide added to the water sample).

Prof. HENTSCHEL carried through the laborious work of counting the different constituents of the plankton, collected by centrifuging 30 c.c. of water. A most striking coincidence with the surface isohalines was exhibited by the density of the peridinians, which were most plentiful in the Atlantic water, rapidly decreasing through the polar front zone towards the Greenland coast. The coccolithophorid *Pontosphaera huxleyi* (which sometimes occurs in such density on the Norwegian coast that the water resembles milk) shows a curious distribution, a tongue of comparatively high values extending east from a centre of maximum near the Greenland coast in about 63° N. Lat. Otherwise it must be assumed that the season of investigation, late summer, was scarcely propitious for an insight into this undoubtedly highly important area of plankton production, which is probably the main source of the food-stuff which eventually nourishes the enormous fish shoals found in the Icelandic waters.

The authors and their co-workers are to be congratulated on this singularly well rounded-off piece of work, and their full account will certainly be received with interest. OSCAR SUND.

BAGGESGAARD-RASMUSSEN and J. P. JACOBSEN. Contribution to the Hydrography of the Waters round Greenland in the Year 1925. Meddelelser fra Kommissionen for Havundersøgelser, Serie, Hydrografi, Bind II, Nr. 10. København, 1930.

Hydrological exchange or interplay between Arctic and sub-Arctic regions and the North Atlantic Ocean is a matter of importance no less to navigators — especially to deep-sea fishermen — than to scientists, interested for the most part from a biological or physical standpoint. Between Canada and north-west Europe there are three main sea passages connecting in greater or less degree the temperate Atlantic regions with those where permanent ice conditions prevail. It is in these passages where transitional hydrographic phenomena are likely to be met with that interactions between the physical peculiarities of each region are to be observed.

Since the inception of modern hydrographic methods the waters between Iceland and north-west Europe have received a fair amount of attention, but west of Iceland, — that is, in Denmark Strait and in Davis Strait and Baffin Bay, — very little systematic work has been done with regard to the subsurface and deeper water layers. A contribution to the hydrography of these latter waters is then opportune.

In 1925, during the months of June and July, the Danish research steamer "Dana" carried out a programme of hydrographical investigation in the southern part of Denmark Strait, between Iceland and Greenland, and in the waters off the south-west coast of Greenland, between latitudes

60° and 70° N. to about 100 miles from land. The most intensive work was done in the region off Godthaab, that is, in the vicinity of Fyllas Bank. Observations consist of temperatures, salinities, oxygen-saturation and hydrogen-ion concentration values, all of which appear in the "Bulletin Hydrographique" for the year 1925. In the compilation of the report upon these data the aid of material from other sources is acknowledged by the authors.

An introductory sketch of previous information regarding the physical relationships of the waters in Denmark Strait, Davis Strait and Baffin Bay — a subject more fully treated by NIELSEN[1]) in 1921 — is followed by an examination of the water-masses found in the summer of 1925 off the south-west coast of Greenland, with particular attention to the cold intermediate layer apparently characteristic of this region in summer and emanating from the East Greenland Polar Current.

To define, physically, this cold stratum of water there is taken the mean of observations from selected stations within the area between latitudes 60° and 63°30′ N., the selection of stations being in accordance with the occurrence of a minimum temperature of less than 1° C. at some depth intermediate between surface and bottom. A mean minimum temperature of —0.24° C., corresponding to a mean salinity of 33.42 ‰ and a mean oxygen-saturation percentage of 97, occurring at an average depth of 51 metres, is thus deduced from the data pertaining to ten out of sixteen stations visited. These values of temperature and salinity, being distinctly different from the corresponding quantities attributable to the East Greenland Polar Current water, namely ca. —1° C. and ca. 34 ‰ respectively, indicate admixture of the water from this current with other waters to be found in Davis Strait.

Farther north, in the shallower region of Davis Strait between latitudes 65° N. and 68°30′ N., a cold water layer again occurred on the Greenland side of the Strait, but at an average depth this time of about 100 metres. The characteristics of this layer, arrived at in the same way as above, are found to be, T = —0.70° C., S = 34.12 ‰ and O_2 sat. = 95 %. The difference between these values and those for the cold layer in the south-eastern part of the Strait is to be accounted for by the difference in origin of the two water-masses, the northerly one probably arising in Baffin Bay during the previous winter period of ice formation.

Between these two areas (i. e. between latitudes 63°30′ N. and 65° N.) transitional conditions were traced in the physical properties of the water-masses occurring there during the summer of 1925, although summer heating of the comparatively fresh water from the melted ice carried north by the East Greenland Polar Current and south from Baffin Bay makes the definition of a cold intermediate layer less sharp, particularly over the shallower "bank" areas. The mean temperature and salinity — calculated from the values pertaining to stations registering more than 70 metres of water — at the depth showing minimum temperature in

[1]) J. N. NIELSEN. The Waters round Greenland. Greenland, Vol. 1, Commission for the Direction of the Geological and Geographical Investigations in Greenland, Copenhagen 1921.

each case, are found to be 0.21° C. and 33.91 ‰ respectively, occurring at an average depth of 113 metres.

On the Disko submarine plateau, separated from the Hellefiske banks by depths in excess of 200 metres, conditions in a vertical sense were, in the summer of 1925, found to be very similar to those in the latter area, minimum temperatures and salinities being practically the same at corresponding depths and the cold layer prominent at from 50 to 100 metres. Oxygen-saturation values at those depths, however, show a distinct difference between the two regions, those of the Disko Plateau being considerably less than those observed over the more southerly banks.

In depths of approximately 500 metres in Davis Strait, off the west Greenland coast, relatively warm and salt water, emanating probably from the Irminger current in Denmark Strait, was recognised by temperatures of about 4° C. and salinities of 34.95 ‰. Oxygen values (92 %) showed a slight sub-saturation "owing to the exclusion of the water from the atmosphere during its passage from Denmark Strait into Davis Strait".

On the basis of the above definitions of characteristic water-masses the authors proceed to discuss the important question of the admixture of these several "types" in Davis Strait. This is facilitated by symbolical representation on T.S.-diagrams, a method which possesses certain advantages[1]) over that of vertical-section diagrams embracing isotherms and isohalines.

The physical properties of the uppermost 50 metres of water in the area off south-west Greenland, from Cape Farewell to Godthaab, are thus demonstrated to have been extremely variable during the period of investigation, temperatures ranging from —1.0° C. to 4.5° C. and salinities from about 32.5 ‰ to 34.70 ‰. Between 50 and 150 metres the ranges of these properties were somewhat less but still fairly extensive, values falling mainly about the straight line joining the points defining Atlantic and Polar water types. Below 150 metres, however, a much nearer approach towards homogeneity is evident from the T.S.-diagram, the bulk of the water at these depths consisting of slightly diluted Atlantic water from Denmark Strait.

A greater concentration of the symbols representing the above delimited water-strata is characteristic of the diagram pertaining to the region of the Hellefiske banks, except in the case of the bottom waters which, as is to be expected from knowledge extant concerning the currents off western Greenland, show considerably more dilution from the Atlantic "type", by admixture no doubt with the fresher, superimposed layer. The latter also is obviously in contrast with the similar stratum off south-west Greenland in that it seems to have been formed by the admixture of cold water from off the Hellefiske banks with the already diluted Atlantic water.

Transitional hydrographic conditions are well portrayed in the T.S.-diagram for the region over and surrounding the Fyllas Bank, while the

[1]) J. P. Jacobsen. Contribution to the Hydrography of the North Atlantic. The "Dana" Expedition, 1921—22; Oceanographical Reports, No. 3. Copenhagen, 1929.

comparatively few data from the Disko Plateau strengthen the earlier conclusion that conditions in this area are very similar to those prevailing a little farther south along the coastal shelf.

By means of the customary vertical-section diagrams the disposition of the various types of water found off south-west Greenland is still further discussed, even proximately coastal conditions being detailed in four such figures. Two almost parallel sections from Iceland to Greenland in the southern part of Denmark Strait are also included in this survey, and in this region the differentiation of waters lying respectively to the south of Greenland and south of Iceland is clearly revealed by the disposition of isotherms and isohalines in the section diagrams.

Off south-west Greenland, especially in the area west of Godthaab, strong currents are indicated by the sloping of isotherms and isohalines in the vicinity of the continental shelf, a circumstance also noted by Martens in his account of the "Michael Sars" investigations[1]) in the same region a year previously. By the aid of Bjerknes's theory the authors of the paper now under review have computed the component velocities of the surface current (a) westward in the southern part of the area in question and (b) northward in the northern part. These work out at 7.3 and 27 centimetres per second respectively, but the figures, it is pointed out, can be accepted only with reserve.

Furnishing a general idea of the horizontal disposition of temperature and salinity off the south-west coast of Greenland during the months of June and July 1925 the authors include in their report two charts, one for the surface and one for a plane 75 metres below the surface, with the requisite datum curves.

With Marten's paper, above quoted, giving account of similar work by the "Michael Sars" in the same areas during the previous summer, the "Dana" report constitutes an advance in our knowledge of the hydrography of an important region where problems relating to ice-formation and ice-drift are at present paramount by reason of their significance from a commercial point of view. Extended investigations similar to those just reviewed will no doubt be of value towards the solution of these problems and also, it may be confidently anticipated, will afford enlightenment on other questions of a biological nature. J. B. T.

H. A. Marmer. The Sea. Pp. 1—301, figs. 1—45, New York, 1930.

H. A. Marmer gives in popular form an account of the methods used, and the discoveries made in the study of the sea. The first six chapters of his book deal with the gradual accumulation of knowledge of the boundaries of the oceans due to early voyages in search of the Indies or Cathay, and in the struggles to attain the Poles. It is to be remarked, however, that the adventurers and explorers mentioned were concerned with the land they strove to reach and not with the water they were bound to

[1]) Erik Martens. Hydrographical Investigations during the "Michael Sars" Expedition, 1924. Cons. Intern. Perm. pour l'Explor. de la Mer. Rapp. et Proc.-Verb. LVI. Copenhagen 1929.

traverse. The history of the ocean as a study in itself appears to begin during the second half of the eighteenth century when Franklin made observations on the course of the Gulf Stream.

Many facts are given in the chapters following concerning the oceans and seas of the world. The tabulated data include the distribution of land and water, the areas, average depths, greatest depths and estimated volumes of the oceans and seas. One feels that undue space has been allowed in the elaboration of these figures — space that might well have been given to a fuller treatment of other sections of the work. For instance, oxygen content and alkalinity are surely important enough to deserve mention even if the methods used in their determination must be excluded.

When the author comes to his own subject of the tides and currents his interest and knowledge are apparent. His explanations are clearly and simply expressed. These chapters are by far the best in the book. The repetition of the description of a simple form of tide gauge (pp. 116, 195 and 209) might have been avoided.

Taken as a whole the work makes interesting reading. J. F. G. W.

F. S. Russell. (a) The Vertical Distribution of Marine Macroplankton. IX. The Distribution of the Pelagic Young of Teleostean Fishes in the Day-time in the Plymouth area. — Journal Marine Biol. Assoc. N. S. Vol. XVI. No. 2. Plymouth 1930.

(b) The Seasonal Abundance and Distribution of the Pelagic Young of Teleostean Fishes Caught in the Ring-Trawl in Offshore Waters in the Plymouth Area. — Journal Marine Biol. Assoc. N. S. Vol. XVI. No. 3. Plymouth 1930.

(a) In this paper Mr. Russell continues his study of the vertical distribution of pelagic young fishes, former papers on which were reviewed in this journal (Vol. I, No. 3; Vol. II, No. 1; Vol. IV, No. 2). A very large amount of additional material has been examined, fifteen stations each with six hauls at determined depths having been made in 1926, supplemented by thirty six oblique hauls with the ring trawl and 114 hauls with the bottom plankton net in 1927 and 1928. These supplemental bottom hauls were made with a view to discovering whether any species frequented the region just above the bottom, out of reach of the ring trawl. The oblique hauls were made for the purpose of providing a simultaneous standard of comparison with the bottom plankton net.

The species which, by inference from previous ring trawl hauls, were looked for near the bottom were: *Gadus minutus*, *Callionymus* sp., *Gobius* sp. and, by day, Herrings and Sprats. As regards the first three of these this inference was confirmed, as it was found that *Gadus minutus*, specimens above 12 mm. long, congregates in great numbers close to the bottom, likewise *Gobius* sp. *Callionymus* sp., however, showed that its maximum concentration, though below 20 metres, was not actually on the bottom and was higher in the water in April and May than in June, July and August. As regards the Clupeoids the evidence was not decisive, as, taking an average over the year, similar numbers were taken in the ring trawl

and in the bottom plankton net, and the much higher catches by night than by day, made with the ring trawl, remain to be explained.

A marked difference between the behaviour of the post-larvae of spring and summer spawning fish has been noted; the former keep in most cases to the layers below about 15 metres while the latter occur mainly from 25 metres to the surface. It is suggested as an explanation that the summer spawners, being mostly fishes with a more southerly distribution, are adapted in their young stages to a higher light intensity or, it may be, to a higher temperature than the winter spawners.

The paper contains notes on the vertical distribution of each of the species observed and concludes with tables of the numbers of specimens taken in the several hauls.

(b) In his second paper Mr. Russell is concerned with arranging his abundant material so as to give a picture of the quantitative abundance throughout the year of the different species of pelagic young fishes occurring off Plymouth. The unit taken is a haul of the 2 metre stramin ring trawl from surface to bottom fished at six successive depths for five minutes at each depth, and the averages per haul for each month in which collections were made have been calculated for each of the six years, 1924—1929. Only off-shore stations have been included. A clear and easily followed diagram sums up in graphic form the monthly averages for each species and, as usual, the full data are given in the concluding tables, together with a bibliography of all papers dealing with the post-larval Teleosteans of the Plymouth Area. G. P. F.

W. E. Allen. Methods in Quantitative Research on Marine Microplankton. Bull. Scrips. Instit. of Oceanography. Tech. Ser., Vol. 2, No. 8, pp. 319—329, Berkeley, 1930.

This paper is a continuation of a series by the author dealing with the Plankton of Southern Californian waters. It may be recalled that the method adopted as standard for the daily collections during the last ten years consisted in dipping 25 litres of surface water, and filtering through No. 25 Dufour bolting silk (average diameter of mesh 0.05 mm.). It was recognised that this method would retain only a certain proportion of the total plankton, but it was assumed that, for the Diatoms, the loss would not exceed 50 %, and would usually be much smaller.

To test the validity of this assumption, the surface sample was collected in the usual manner, 1 litre being put aside for gravity concentration, and the remaining 25 litres being filtered. The smaller sample, which we may conveniently refer to throughout as the settlement catch, was allowed to stand in a graduated cylinder of 1 litre capacity until the plankton settled. The supernatant liquid was decanted off, and the sample gradually reduced to small bulk. The author does not mention the time required for concentration, nor, beyond stating that "there is more or less loss of very light organisms in decanting....", does he give any indication of what proportion of the total plankton is missed. The two methods of collection have been carried out during the whole of 1929, but the author discusses only 12 of the daily samples obtained during January.

The main findings can be summarised briefly as follows:— The (smaller) settlement catches contained fewer species than the filtration on 8 occasions, more on 3 and the same number on 1 occasion; the means being 12 by settlement and 13 by filtration. (From Table 1, p. 321.) In 9 out of 12 cases the number (per litre) of Diatom cells was larger in the settlement catches; the means being 31,675 (settlement) and 26,730 (filtration). For the small Dinoflagellates occurring in January the mean numbers (per litre) were 4,475 and 495, the settlement catches being in every case the bigger.

These results are what one would expect if smaller (and non-chain-forming) organisms escape the net. Similarly, one would expect to find shorter filaments of those chain-forming Diatoms which might, in small aggregations, pass through the net. Comparing the species we see that the mean number of cells per occurrence and the mean number of cells caught are as follows:— (From Table 2, p. 323)

	by settlement		by filtration	
Species	Mean No. Cells	Mean No. Cells per Occurrence	Mean No. Cells	Mean No. Cells per Occurrence
Nitzschia seriata Cl.	13,987	2.67	12,082	3.84
Pseudoeunotia doliolum W..	917	4.09	424	5.4
Chaetoceras spp.....	14,287	8.3	14,703	6.5

These results tend to confirm this assumption. For *Chaetoceras* spp., which by reason of their setae should be retained by the filtration method to a higher extent than the other species, the numbers shew a slight excess for this method, but probably well within the normal errors of sampling and enumeration, as, indeed, is that for *Nitzschia* also. The settlement catch contains, however, longer chains. This result, which has been arrived at from the figures in Table 2, p. 323, is the reverse of that given by the author who states, p. 325, that — "the slightly more favorable showing of the filtration catches is certainly caused by the larger sample's getting more large colonies than the small sample". He states, further, that — "the error may run in the reverse direction if the small sample happens to include an exceptionally large colony", and mentions two catches (Nos. 2918 and 2919) where this occurred. It should be noted, however, that the number of cells per occurrence is greater in the settlement catches on 8 occasions, and the suggestion is made now that the filaments may be broken during filtration processes.

The author points out (Comparability of Records) that this experiment demonstrates that "catches made by different methods are not, necessarily, comparable because they are discussed in the same terms, or because their contents are calculated in the same units," and in so doing has laid his finger upon a weak spot in much of marine planktological research. The imposing array of tables which are alleged to represent numbers of organisms per unit volume of sea water, and the elaborate graphs, are apt

to mislead unless the limitations of the particular method employed in their construction are fully realised.

For the particular purposes that the author had in view, namely a comparison of daily samples from several stations over a long period of years, his filtration method may be the only one possible. But, as he points out, it has its limitations. The present paper is useful in drawing attention to these, and it is, perhaps, not too much to hope that more work of this kind, which is badly needed, will be undertaken in order gradually to eliminate the less satisfactory methods, and to arrive at a standard world-wide methodique. A. C. G.

H. H. Gran and Thomas G. Thompson. The Diatoms and the Physical and Chemical Conditions of the Sea Water of the San Juan Archipelago. Publ. Puget Sound Biol. Station. Vol. VII. Washington, 1930.

Der San-Juan-Archipel ist zwischen dem Südende der Insel Vancouver und dem amerikanischen Festlande gelegen und steht im Westen durch die Strasse San-Juan-de-Fuca mit oceanischem Wasser, im Norden mit dem Wasser des Golfs von Georgia, das durch den Fraserfluss ausgesüsst wird, in Verbindung. Die 7 untersuchten Stationen lagen zum Teil in dem den Archipel durchsetzenden San-Juan-Kanal, zum Teil in dem 12 km langen blind geschlossenen Ostsund (East Sound), z. T. in der San-Juan-de-Fuca-Strasse. Die Untersuchung bezog sich auf Temperatur, Chlorgehalt, Sauerstoffgehalt, Dichte, osmotischen Druck, Wasserstoffionenkonzentration (Thompson) und Diatomeengehalt (Gran). Sie gründete sich auf Schöpfproben aus 5, 10, 20 m u. s. w. bis im Maximum 225 m.

Der San-Juan-Kanal zeigte im mittleren Teil durch die sehr gleichmässige Vertikalverteilung der Diatomeen starke Wassermischungen an, eine Folge der Tidenströme. Am Nordende liess sich jedoch an Temperatur, Sauerstoffgehalt, Dichte und Diatomeengehalt (quantitativ und qualitativ) eine sehr deutliche Schichtung erkennen: Wassermassen aus dem Golf von Georgia überlagerten solche aus der San-Juan-de-Fuca-Strasse.

Der abgeschlossene Ostsund zeigte starke Diatomeenwucherung, bis zu 2000 Zellen im Milliliter. Von aussen nach innen nahmen Temperatur und Sauerstoffgehalt zu, Dichte und Chlorgehalt ab. Vertikale Unterschiede waren sehr deutlich. In 5—10 m Tiefe schob sich eine planktonarme und sauerstoffarme Zwischenschicht ein, wohl Bodenwasser, das durch in der Tiefe eindringendes dichteres Wasser gehoben war. Trotz beträchtlichen Wasseraustausches durch Tiden zeigte die Diatomeenflora Züge lokaler Eigenart. In diesem Sund wurde auch die Tiefenlage des Gleichgewichtszustandes zwischen dem durch Photosynthese frei werdenden und dem durch Respiration verbrauchten Sauerstoff festgestellt. Sie war gering, 10—20 m, wohl infolge starken Gehalts des Wassers an das Licht hemmenden schwimmenden Partikeln.

In der San-Juan-de-Fuca-Strasse waren drei Wasserschichten zu unterscheiden, Oberflächenwasser, Mittelwasser und ozeanisches Tiefenwasser. Dies letzte, das an der äussersten Station die Hauptmasse ausmachte, zeigte durch Sauerstoffarmut und wenige, wohl nur abgesunkene Diatomeen, dass es lange nicht für die Photosynthese genügende Lichtmengen

bekommen hatte. Im allgemeinen ist es das Mittelwasser, das das Gebiet des Archipels beherrscht.

Da die Diatomeenflora dauernd reich ist, muss eine dauernde Nährstoffzufuhr stattfinden, entsprechend dem ersten der drei von GRAN durch ihre Diatomeenentwicklung gekennzeichneten Wassertypen (vergl. Journ. Cons. Vol. IV, p. 349). Die Zufuhr beruht wohl z.T. auf dem Einfluss des Fraserflusses, z.T. auf Tidenströmungen, dagegen nicht, wie an der Kalifornischen Küste auf aufsteigendem Tiefenwasser. Für ein genaueres Verständnis dieser Verhältnisse halten die Verfasser eine Mitberücksichtigung der Phosphate und Nitrate bei der Fortsetzung der Untersuchungen für notwendig. E. HENTSCHEL.

R. S. WIMPENNY. Preliminary Observations on the Fat-Content of the Plankton on the English Herring Grounds in the North Sea. Ministry of Agric. & Fish. Fishery Investigations, Ser. II, Vol. XI, No. 5, 1929. London, 1929.

That there are changes in the fat-content of animals during the various metabolic cycles of their lives is well known, and has also been shown to occur in fishes. Usually there is a definite increase in the fat-content of the body just before the period of reproduction. This sudden accumulation of fat must owe its origin to the food previously eaten by the animal, and with this point in mind Mr. R. S. WIMPENNY has made preliminary estimations of the fat content of the plankton upon which the North Sea herring feed.

On the basis of MEIG's method of estimating the fat in milk, the ether-soluble fat-content of the plankton was estimated for a number of stations in the North Sea during the months of June, August, September and October in 1926. The results were based on collections made by vertical hauls with the coarse international net. By counting the identifiable remains of the macerated plankton an estimate of fat-content was expressed as the ether-soluble matter in milligrams per 1000 organisms.

For the four months in question the fat-content of the plankton was greatest in August, when there was a temperature of 13° C. and salinity of 34.40 $^0/_{00}$. The author compared the fat content in different localities with the catches of herring landed by the drifters in the months in question and there was an indication that the maximal fat-content of the plankton showed a gradual movement from North to South coincident with the movements of the herrings themselves.

No definite connexion could be found between the fat-content and the colour of the plankton. Two observations made on the vertical distribution showed somewhat unexpectedly that if anything there was more fat to be found in the deepest samples.

Mr. WIMPENNY notes that this is only a preliminary paper, but he has stressed the importance of a continuance of similar and more detailed research, together with full chemical and physical observations of the surrounding water. The zooplankton has not received its due attention from the chemical standpoint and it is to be hoped that in the future our knowledge in this direction will be widely increased. F. S. R.

Marie V. Lebour. The Larval Stages of *Caridion*, with a Description of a New Species, *C. steveni*. Proc. Zool. Soc. of London. Part 1, pp. 181—194. London, 1930.

In 1910 G. O. Sars described the development of two Decapod larvae (from S. Norway) which he attributed to *Pandalus borealis* and *P. bonnieri*. Of »*Pandalus borealis*« he found all larval stages, except the last (ninth) one, as well as the post-larval stage; he had only a few stages of the larvae of »*P. bonnieri*«. Sars' larvae of »*P. borealis*« were not hatched from the parent and were not kept in captivity until one stage changed to the next; all the stages were found in the plankton, and from their likeness to the post-larva the whole series of larvae was attributed to this species. The second — not complete — series of larvae was attributed from its likeness to the first series to another species of Pandalus, *P. bonnieri*.

In the present paper Dr. Lebour reports on some investigations made in the Plymouth laboratory and states that Sars' identification is incorrect, in that the larvae concerned belong to *Caridion gordoni* (Sp. Bate) and to *C. steveni* n. sp. respectively (it may be noted that *Pandalus borealis* is a northern species, never found in British waters, and *P. bonnieri* is not known from S. England).

The adult *Caridion gordoni* has not as yet been found in Plymouth waters, and thus it was impossible to obtain the larva from eggs; but the larval stages (except the two first, which were not found) are frequent from April to September, and the post-larvae (living in or near the bottom) from June to September. Miss Lebour was not fortunate enough to get the larvae to change from one stage to the next, under laboratory conditions, except the last (ninth) stage which was kept alive with small pieces of prawn and shrimp as food, and which changed into the post-larval stage, and this again (in from seven to eight days) to the first young stage. Thus Miss Lebour was enabled to fill up the gap in Sars' series, and the larvae could be attributed to the true species.

The second larva, which Sars referred to *Pandalus bonnieri*, is easily distinguished from all other larvae in having two large curved horns on the dorsal side of the carapace; it hatched from eggs. The adult, which Dr. Lebour calls *Caridion steveni* n. sp., is so closely allied to *C. gordoni* that were it not for the very different larva it would seem rather doubtful to establish a new species on the adult. *Caridion steveni* differs from *C. gordoni* in being stouter, with slightly shorter appendages but longer antennae, and the abdominal segments not quite as deep; the rostrum is deeper and shorter, not reaching quite to the apex of the antennular peduncle, never exceeding it. It lives in rocky pools under stones at low tide and between tide-marks, while *C. gordoni* is probably never found in depths less than 20 m., rocky, sandy or muddy bottom, and may extend to more than 450 m. (Bay of Biscay). The adult *C. steveni* has been found in several places round the coasts of Great Britain, and the larvae in S. Norway, in the North Sea and at Heligoland; thus the species must have a rather wide distribution, but has probably been confused with *C. gordoni*.

Sars had only a few larval stages of *C. steveni*; Miss Lebour has been happy enough to hatch them from eggs. Unfortunately the first larval

stage (without dorsal horns) did not change any further, and thus it was not possible to obtain the horned stages from them. It is, however, practically certain that the horned larva really does belong to this species, for the post-larva and the young from it agree much more with this species than with *C. gordoni*. Moreover, *C. gordoni* most certainly came out of the other larva. The second stage of the larva of *C. steveni*, in which the horns first appear, although found only once in the plankton and then not perfect, agrees with the first stage in all essentials and is about the right size. For these reasons this larva is taken to be that of *C. steveni*.

C. steveni has (like *C. gordoni*) 9 larval stages, the 9th of which changed into the post-larva, and this again into the first young stage. Females with eggs were found from January to May, larvae in the plankton from March to early August, post-larvae in August.

These investigations are very interesting since, as regards the identity of the species, they have in all probability proved the development of two northern species of Carids. Strangely enough it has been possible to trace a prawn new to science in these rather well investigated northern waters. Further the removal of Sars' larvae from *Pandalus* clearly shows that certain characters are common to that genus and its close relatives and in many ways clears up some anomalies which were puzzling the workers dealing with crustacean larvae. K. Stephensen.

H. B. Moore and R. G. Neill. An Instrument for Sampling Marine Muds. Jour. Mar. Biol. Assoc., N. S., Vol. XVI, No. 2, pp. 589—594. Plymouth, 1930.

Yet another bottom-sampler has been introduced, and the special claim for this hand-operated model is that it gives a column of mud, from 8—16 inches long, with the successive layers (especially the soft uppermost layer) in undisturbed sequence, and in a form convenient for visual examination and subsequent chemical analysis of serial sections. Details of construction and measured diagrams are given, so that it should be easy for any mechanic to reproduce the instrument. Actual results obtained in use appear to justify the claims made for the instrument (*vide* following review).

Constructionally, one or two features are open to criticism, but it must be admitted that under the complex conditions of actual use, considerations of theoretical mechanics are not always applicable. 1) The abrupt increase of diameter where the projecting sheath joins the body-tube — an actual trebling in the case of the narrowest sheath — must surely obstruct the free passage of the sampler into the muddy deposit, and it would seem that the necessary weight could more effectively have been obtained by using a shorter and thicker body-tube of stream-lined section, with the narrow sheath of the sampling tube projecting freely for its full length. 2) The valve mechanism, involving as it does a glass-to-glass joint, is liable to damage, and might be replaced by a glass ball and rubber gasket of the familiar "ginger-beer bottle" type. 3) The instrument is constructed so as to take three different sizes of glass sampling tube, appropriate to the coherency of different deposits, but, when the narrowest (0.95 in.)

tube is used, it is not clear, from the details given, what prevents the tube from being forced up through the sheath by the friction of the entering deposit, and damaging the valve above. 4) Finally, it may be suggested that a very slight thickening of the free end of the sheath would facilitate its penetration of the mud by reducing friction against the proximal part of its walls.

A propeller, fitted to the tail-shaft, conduces to steady rectilinear travel, but in common with other samplers, the taking of a truly vertical boring can only be judged from the appearance of the sample.

J. R. B.

H. B. Moore. The Muds of the Clyde Sea Area. I. Phosphate and Nitrogen Contents. Jour. Mar. Biol. Assoc., N. S. Vol. XVI, No. 2, pp. 595—607. Plymouth, 1930.

The investigation of the chemical and physical factors which affect life on the sea-floor is a natural extension of the line of research established at the Millport Marine Station, in Marshall & Orr's work (l. c. XIV) on the relation of the plankton to its changing physical environment, in the Clyde Sea Area. Conditions on the bottom, however, are more complex than in the waters, and the author rightly regards this as a preliminary statement which further investigation may modify.

Core-sampling of the muddy deposits was carried out by means of the bottom-sampler described in the preceding note, the core being cut up for analysis into 5 cm. lengths. The phosphate content of the dried material was determined by the phosphomolybdate method, and the total nitrogen by Kjeldahl. Phosphate values from the different stations range between 0.117 and 0.406 % P_2O_5 (on dry weight) in the upper 5 cm., and while nearly all stations show a falling-off in phosphate content at greater depths in the mud, the decline is not continuous — an unexplained kink occurring at 10—15 cms. Apart from this, there is no apparent correlation between actual depth of bottom and phosphate content, and this applies equally to the nitrogen values. A fairly good linear relation exists between % P_2O_5 and % N_2, at all stations, except, as might be expected, in the disturbed upper 5 cm. layer.

The results, while admittedly drawn from too limited and too complex an area to permit of broad generalisation, are a definite step towards an evaluation of the nutritive-cycle between the sea-bottom and the upper waters in the Clyde Sea Area, similar to that which has for so long been shown to exist by Petersen, Blegvad, and others, in Danish waters.

J. R. B.

D. M. Reid. Salinity Interchange between Sea-Water in Sands and Overflowing Fresh-water at Low Tide. Jour. Mar. Biol. Assoc., N. S. Vol XVI, No. 2, pp. 609—614. Plymouth, 1930.

The influence of varying salinity is doubtless one of the most potent factors in the ecology of the sea-shore, and at the same time one of the most difficult to assess. The author has here attempted to determine the

salinity *in situ* at different depths in the sand of a N. Scottish beach, and concludes that the flowing of a fresh-water stream over the surface of an intertidal sand has a negligible effect upon the salinity (and presumably upon the in-fauna) of the interstitial water, at depths in the sand greater than 10 inches. This, however, does not apply to shallow sands with underlying rock, where the washing effect extends, for various reasons, to a much greater depth. An attempt is made to explain the salinity range at successive points between high water mark and low water mark as dependent upon the relative periods of submergence by the tide, but so intimately are salinity and other differences bound up with local topographical detail (contour, sand-grade, impermeable strata, etc.) as well as with hydrostatic effects due to subsurface waters, that no direct correlation would seem to be justified without a full specification of the local data. At the same time, this short investigation, involving only the simplest of technique, is a useful survey of the salinity-conditions in a specified area. It is only by such detailed local surveys that we can hope ultimately to gain a real insight into the complex physical and biological conditions which affect living things on the sea-shore. J. R. B.

A. C. Johansen. The Aalborg Herring and its Importance to the Danish Herring Fishery from the XVIth Century until the Present Day. Report of the Danish Biological Station to the Ministry of Shipping and Fisheries. XXXV. 1929. pp. 3—47. Copenhagen, 1929.

All who are interested in Danish Fisheries are familiar with the Limfjord but probably its past history is not known to many outside Denmark. In the present paper Dr. Johansen traces the changes which, during the past four hundred years, this stretch of water has undergone and the consequent alterations in the habits of the Herring which frequent it. At the present day the Limfjord consists, in its western part, of a number of wide stretches of water, the broads, joined to each other by narrower channels and communicating with the North Sea by a navigable opening, the Thyborøn Canal, which pierces the narrow strip of land, the Agger Isthmus, separating Nissum Broad from the North Sea. The Broads are also connected with the Kattegat by a river-like channel on which Aalborg is situated, which widens midway into the Nibe Broad.

In the XVIth and the beginning of the XVIIth Century the Agger Isthmus formed a continuous barrier between the Limfjord and the North Sea, with the result that the broads formed a series of fresh or slightly brackish inland lakes, discharging into the Kattegat and supporting, as existing records show, a freshwater fauna. The Aalborg channel, through its sea connection, was, however, sufficiently salt to allow of herring making their way up it in such numbers as to support a very valuable fishery.

In 1624 the narrow strip separating the Limfjord from the North Sea was broken through, the salt water invaded the broads and sea fish took the place of the freshwater fish which had perished. The breach in the Agger Isthmus, however, filled itself again after a few years and the broads regained their freshwater fauna, the herring, which had extended their

range, being again restricted to the eastern sea connection with its Nibe extension. These conditions lasted for nearly two hundred years till, in 1825, the western coastline was again breached, this time permanently, and the Limfjord assumed its present conditions, the breach being maintained for purposes of navigation.

The herring formerly frequenting the eastern part of the Limfjord about Aalborg resembled so closely in their habits, spawning periods and migrations those now found in the same locality that it is inferred that they belonged to the same race which now migrates between the fjord and the Kattegat and Skagerack. Investigations of characters of this race, vertebrae, keeled scales and fin rays, show that there is a general agreement between the Limfjord spring spawning fish and samples taken in the Kattegat and Skagerack. Two samples of spring spawners from Thisted and Nissum Broads in the western part of the fjord were found to have a slightly higher number of vertebrae and are referred to North Sea herring which have entered through the opening in the Agger Isthmus. One result of the breaking through of the isthmus was that, whereas previously the spawning places of the Aalborg herring were confined to the eastern channel of the fjord, now there are several spawning places in the broads in the western part of the fjord. It is also shown that two autumn spawning races of herring make their way into the western part of the Limfjord from the North Sea, viz. the West Jutland Autumn herring and the North Sea Bank herring, the latter occurring at times in large numbers but only in their first two years. These young herring are known as "Sild-ing" and are the subject of a considerable fishery.

In considering the yield of the Limfjord herring fishery, for which detailed data are available from 1859 to the present time and more or less approximate records for earlier periods, Dr. Johansen points out that there are evidences of two kinds of fluctuations, those for short and long periods. The short period fluctuations are explained as due to the occurrence of good and bad seasons for the development of the fry. The long period fluctuations are not so easily accounted for. Alterations in the hydrographic conditions owing to the opening of the gap in the isthmus, periods of scarcity due to over fishing, heavier yields due to more intensive fishing or improved methods of capture may all have had a part in producing the observed effects.

Dr. Johansen has produced a most interesting study from all points of view, except that of age distribution, of a fishery carried on under rather unusual conditions. G. P. F.

Henry Wood. Scottish Herring Shoals. Prespawning and Spawning Movements. Fisheries, Scotland, Sci. Invest., 1930, 1. Edinburgh, 1930.

Der Verfasser behandelt in seiner Veröffentlichung drei Heringsfischereien, welche sich in schottischen Gewässern und in deren Nähe abspielen, die Grosse Sommerfischerei, die Deutsche Trawlheringsfischerei und die Frühjahrsfischerei.

Für Grossbritannien ist die Grosse Sommerfischerei wirtschaftlich

am wichtigsten. Sie beginnt im Mai im NW. und W. der Shetlandinseln. Im Juni setzt der Fang an der Ostküste in tiefem Wasser von mehr als 60 Faden ein und rückt mit dem Fortschreiten der Saison allmählich in flachere küstennahe Gebiete bis hinunter nach Aberdeen. Ende September schliesst die Saison. Westlich der Shetlands werden fast ausschliesslich Frühjahrsheringe gefangen, in der Nordsee ein Gemisch von Frühjahrs- und Herbstlaichern.

Die Herbstheringe scheinen sich kurz vor der Erlangung der Geschlechtsreife in tiefem Wasser zu sammeln, um dann zum Laichen in flacheres Wasser aufzusteigen. Aus dem Vorkommen laichender und abgelaichter Tiere versucht der Verfasser ihre Laichplätze zu lokalisieren und kommt zu dem Schlusse, dass diese bei Shetland längs des schmalen Abhanges der SE.-Küste und auf dem Rücken zwischen Sumburgh Head und Fair Isle sowie auf der Fair Isle Bank liegen, wo der Boden aus Schalen besteht und die Wassertemperatur am Grunde ungefähr $+10°$ C. beträgt. Bei den Orkneys und bei Caithness liegen bedeutende Laichplätze innerhalb der 40 Faden Linie, ebenso auf der Smith Bank. Weiter südlich wird dicht unter der Küste am S.-Eingange des Moray Firth und längs der schottischen Küste bis Montrose wie auf der Turbot- und der Montrose Bank gelaicht. Es ist anzunehmen, dass die Herbstheringe vornehmlich in einer Tiefe von 10—40 Faden laichen und die 50 Faden Linie wohl nicht überschritten wird. Die Laichzeit beginnt frühestens Ende Juli, erreicht ihre volle Intensität Mitte August und zieht sich manchmal bis Mitte Oktober hin. Die grossen alten Fische laichen früher als die kleinen jungen. Auf der Unst- und auf der Viking Bank wird im Herbst nicht gelaicht.

Es folgt eine Beschreibung der Trawlheringsfischerei auf dem Fladengrunde. Der Verfasser fand, ebenso wie die deutschen Beobachter, im Verlaufe der Saison nur geringe Fortschritte in der Reife der dort gefangenen Heringe. Da er zudem für 1924 (ebenfalls in Uebereinstimmung mit den deutschen Befunden) eine von den Fladenheringen abweichende Alterszusammensetzung der mit dem Treibnetz in der Nähe der Küste gefangenen Heringsschwärme feststellte, schliesst er daraus, dass die Fladenheringe zu einem grossen Teile Frühjahrslaicher sind. Zweifellos gibt es davon auf dem Fladen nicht unbeträchtliche Mengen, doch dürfte das von Jahr zu Jahr wechseln und die Schwärme im wesentlichen aus Herbstlaichern bestehen. 1927 z. B. herrschten auf dem Fladen und an der Küste dieselben Jahrgänge, zudem lässt sich das Auftreten jüngerer Heringe an der Küste durch die geringere Wassertiefe erklären.

Die Frühjahrsfischerei beginnt im Januar und dauert bis Ende März oder Mitte April. Sie ist von geringer wirtschaftlicher Bedeutung, da die grossen, sehr reifen oder abgelaichten Heringe ein grobes Fleisch haben und sich zum Salzen nicht eignen. Daher sind, trotz grosser Heringsmengen, die Fänge nur klein. Die besten Fangplätze wurden von Langleinenfischern bei der Suche nach Köderfisch gefunden. Sie liegen hauptsächlich im Westen, im Minch und an der N.- und W.-Küste von Sutherlandshire bei den Inseln Handa und Bulgie. In der Nordsee selbst treten nur wenig ergiebige Heringsschwärme an der Küste von Caithness, bei den Orkneys und Shetlands auf. Die Hauptlaichplätze der Frühjahrsheringe liegen an der schottischen NW.- und W.-Küste in 40 Faden Tiefe, und im NW

der Shetlands von Balta Sund bis St. Magnus Bay bis zu 20 und 30 sm von der Küste in 50—80 Faden. An der schottischen NE.- und E.-Küste ist nur eine geringe Laichtätigkeit zu beobachten. Die Laichzeit dauert von Anfang Februar bis Ende März.

Im Firth of Forth werden von Oktober bis April ein- und zweijährige Heringe mit den verschiedensten Netzen gefangen, Anfang Januar beginnt an der Küste eine Treibnetzfischerei auf Heringe, die von Mitte Februar bis Mitte März in weniger als 30 Faden Tiefe laichen, und die zum Frischverbrauch fast ausschliesslich in Anstruther und Eyemouth gelandet werden. Im April ist diese Fischerei beendet.

Von Angelfischern und Trawlern werden im Frühjahr gelegentlich auf der Viking Bank Heringe erbeutet, die dort wahrscheinlich von Mitte Februar bis April in 60—70 Faden Tiefe laichen. Sie kommen entweder von Norwegen oder von Shetland und sind stets mit Herbstlaichern gemischt.

Sämtliche hier erwähnten Laichplätze für Herbst- und Frühjahrsheringe sind in einer Uebersichtskarte verzeichnet. Ein Vergleich dieser mit der 1923 von Dr. Bowman entworfenen, erweist den Fortschritt der Untersuchungen in dieser Zeit. Die Arbeit von Wood bereichert unsere Kenntnis der Lebensweise und der Fischerei des Herings so wesentlich, dass ihrer Fortsetzung, behandelnd die Alterszusammensetzung der schottischen Heringsschwärme, mit grossem Interesse entgegengesehen werden darf. H. L.

E. Ford. Herring investigations at Plymouth. VIII. The transition from larva to adolescent. Journ. Mar. Biol. Ass. N. S., vol. XVI, no. 3, Plymouth, 1930.

In der Reihe der Veröffentlichungen über Untersuchungen am Hering befasst sich E. Ford in der vorliegenden Abhandlung mit dem verschiedenen Wachstum einzelner Körperabschnitte während der Metamorphose. In erster Linie handelt es sich dabei um die bereits viel erörterte Frage nach der Beziehung von Rückenflosse, Bauchflossen und After in ihrer Lage zueinander und zu den Wirbeln. Es werden zunächst die Verschiebungen, welchen die genannten Körperstellen unterworfen sind, im einzelnen näher erläutert. Von diesen Tatsachen ausgehend, werden von Ford dann einige Schlussfolgerungen gezogen, die von grundsätzlicher Bedeutung sind. Es handelt sich dabei zunächst um die Frage nach dem Zusammenhang dieser Verschiebungsvorgänge mit der Gesamtzahl der Wirbel. Es wird festgestellt, dass, je grösser die Gesamtzahl der Wirbel ist, desto höher auch der mittlere Wirbelwert ist, der für die Lage des ersten Flossenstrahls der Dorsale und des Afters in Betracht kommt bei einer gegebenen Stellung der Bauchflossen. Mit anderen Worten, je grösser die Gesamtzahl der Wirbel ist, desto weiter hinten liegen durchschnittlich der erste Strahl der Rückenflosse, die Bauchflosse und der After.

Die Frage nach der Ursache der Lageverschiebungen ist nun von grosser Bedeutung. Wie auch bereits von anderen Seiten geäussert wurde, so vertritt auch Ford die Ansicht, dass es sich um Wachstumsverschiebungen handelt. Welcher Art diese Wachstumsverschiebungen sind, das

versucht Ford in sehr interessanter Weise zu erklären. Er geht davon aus, dass die Abstände von Bauchflossen zum After und vom Hinterhaupt bis zur Basis des ersten Rückenflossenstrahls während der Entwicklung eine erhebliche Verkürzung im Verhältnis zur Gesamtkörperlänge erfahren. Auf dieser Erkenntnis aufbauend verfertigt Ford ein Modell, das aus drei parallel zueinander liegenden Bändern besteht, die horizontal zwischen zwei vertikalen Holzstäben ausgespannt sind. In dem oberen Streifen besteht die (vom Beschauer gesehen) linke Hälfte aus unelastischem, die rechte aus elastischem Band. Der mittlere Streifen ist in seiner ganzen Länge elastisch. Beim unteren Streifen dagegen ist das Mittelstück in $^1/_2$ der Gesamtlänge unelastisch, während die beiden Enden in je $^1/_4$ der Gesamtlänge elastisch sind. Die beiden genannten unelastischen Abschnitte entsprechen den Abständen Hinterhaupt-1. Dorsalstrahl und Bauchflossen-After. Fasst man nun die beiden vertikalen Holzstäbe an und entfernt sie voneinander, was dem Vorgange des Gesamtwachstums entsprechen würde, so verschieben sich infolge der Verschiedenheiten der drei Streifen in ihrer Elastizität einzelne Punkte in ihrer Lage zueinander ganz erheblich. Es lässt sich nicht leugnen, dass dieses Modell in seiner Anordnung und Wirkungsweise einen ebenso interessanten wie hübschen Versuch darstellt, die Wachstumsverschiebungen zu erklären, und dass der Endeffekt in der Wirkung des Modells in manchen Punkten den Verhältnissen bei der Entwicklung der Heringslarven nahe kommt. Aber andererseits darf man nicht verkennen, dass sich auch manche Einwendungen gegen diesen Vergleichsversuch machen liessen.

Die genannte Methode zur Erklärung der Lageverschiebungen wird dann noch weiter zur Untersuchung der Proportionsveränderungen durchgeführt. Alle diese Erwägungen, und das wird besonders hervorgehoben, haben aber zur Voraussetzung, dass die Abstände Hinterhaupt-1. Dorsalstrahl und Bauchflossen-After absolut von gleicher Länge während der Metamorphose bleiben. Es wird zwar zugestanden, dass gewisse Veränderungen in der Länge der genannten Abschnitte erfolgen, jedoch werden diese nicht für so bedeutend gehalten, dass dadurch die Theorie ernstlich erschüttert werden könnte. Es darf aber betont werden, dass gerade hier Angriffspunkte gegen den Erklärungsversuch liegen.

Ford stellt dann weiterhin interessante Tatsachen betreffs der Lageverschiebungen der Flossen in Bezug auf die Länge der Larven und die Zeit des Fanges fest, sowie ferner der durchschnittlichen Wirbelzahl in Bezug auf Individuallänge und Fangzeit. Er kommt dabei zu dem Ergebnis, dass die Individuen einer bestimmten Grössengruppe in den Proben, die einer späteren Fangzeit entstammen, weiter in der Metamorphose fortgeschritten sind als diejenigen aus einer früheren Fangzeit. Weiter wird gezeigt, dass die mittlere Wirbelzahl bei den Proben verschiedener Fangzeiten schwankt, und dass in ein und derselben Fangprobe eine niedrigere Wirbelzahl mit einer weiter fortgeschrittenen Metamorphose zusammenfällt.

In einem Schlussabschnitt erörtert der Verfasser die Ergebnisse seiner Untersuchungen im Hinblick auf die Rassenuntersuchungen. Auch hier neigt der Verfasser der Ansicht zu, dass die Verschiedenheiten in den Entwicklungsvorgängen und morphologischen Eigentümlichkeiten zu den von aussen einwirkenden Bedingungen in Beziehung stehen.

Schnakenbeck.

J. J. Tesch en B. Havinga. Rapport over de Zeebliek. Dep. v. Binnenlandsche Zaken en landbouw. Versl. en Meded. van de Afdeeling Visscherijen Nr. 14. s'Gravenhage, 1930.

Die Frage, die dieser Untersuchung zu Grunde liegt, ist die, zu welchen Heringsrassen die als »Bliek« bezeichneten jugendlichen Heringe in den niederländischen Küstengewässern gehören. Eine grössere Fischerei auf diese Jungheringe findet in der Hauptsache in der Oosterschelde, im Haringvliet und in der Zuiderzee statt, meist in den Wintermonaten. Für die Rassenverhältnisse in der SW.-Nordsee von grosser Bedeutung ist die Feststellung, dass in den holländischen Küstengewässern Angehörige von 3 Rassen unter den jugendlichen Heringen vorhanden sind. Die Vermischungsverhältnisse sind ganz verschieden. Diese Ergebnisse werden in einwandfreier Weise durch Wirbelzählungen bewiesen. Bei dieser Beweisführung wird mit Erfolg der Variabilitätsmodus angewandt, der bessere Ergebnisse liefert als die Mittelwerte. Von Bedeutung ist auch der Hinweis auf die Verschiedenheiten in der Lebensweise. Der »Bliek« in den Zuidhollandsche stroomen kommt dort während des ganzen Jahres vor, und die Fischerei darauf liefert regelmässige Ergebnisse. In den Zeeuwsche stroomen ist der Fang sehr unregelmässig. Es wird daraus der Schluss gezogen, dass der hier gefangene »Bliek« in der offenen See zu Hause ist und nur zeitweise in Scharen in die Oosterschelde zieht.

Betreffs der Rassenzugehörigkeit der »Bliek« kommen die Verfasser zu dem Schluss, dass die im Winter in der Oosterschelde vorkommenden »Bliek« jugendliche Individuen der bisher als West-Kanalhering bezeichneten Rasse sind. Einen ganz anderen Charakter weisen die »Bliek« in den Zuidhollandsche stroomen auf. Hier wird ganz deutlich das Vorhandensein von jugendlichen Bankheringen nachgewiesen. Allerdings sind diese Schwärme nicht immer ganz rein, sondern in manchen Jahren zeigen sie Beimischungen (bis wenigstens 50 %) von jugendlichen Küstenheringen. Im Hinblick auf diese Verhältnisse, dass also im nördlichen Teil des untersuchten Gebietes Bankheringe vorherrschen, im südlichen Teil dagegen Kanalheringe, ist die Feststellung von grösster Bedeutung, dass in dem dazwischen liegenden Gebiet, Grevelingen, eine so starke Vermischung vorhanden ist, dass eine quantitative Analyse der Rassen nicht möglich ist. Wahrscheinlich kommen hier alle drei Rassen vermischt vor. So hat sich ergeben, dass im Frühjahr 1926 dort Küstenheringe in grossen Mengen anzutreffen waren, die aber im Sommer vollkommen fehlten. Im Herbst wiesen untersuchte Proben stark auf das Vorhandensein von Kanalheringen hin, während im Winter 1926/27 zur Hauptsache Bankheringe vertreten waren.

In einem besonderen Abschnitt werden noch einige Bemerkungen über den »Bliek« des Küstenherings gemacht, sowie über Wachstum und Nahrungsaufnahme der Jungheringe. Ferner sind auch Larven auf ihre Rassenzugehörigkeit untersucht. Auch unter den Larven wird das Vorhandensein von Kanalheringen wie Bankheringen festgestellt. Bedeutungsvoll ist, dass weder unter den »Bliek« noch unter den Larven das Vorhandensein des »Ost-Kanalherings« festgestellt werden konnte.

In einem Schlussabschnitt wird noch eine sehr aufschlussreiche Statistik über den Fang von jugendlichen Heringen in Holland, England und Deutschland gegeben. Schnakenbeck.

BJARNI SAEMUNDSSON. Die isländische Seefischerei. Handbuch der Seefischerei Nordeuropas, Bd. VII, Heft 4 (89 pag., 57 fig. and 1 chart). Stuttgart 1930.

In the large German work "Handbuch der Seefischerei Nordeuropas" the well-known Icelandic biologist Dr. BJARNI SAEMUNDSSON has published a most interesting paper on the sea fishery of Iceland.

The introduction gives a short account of the history of Iceland, the climate, and the hydrography and fauna of the waters surrounding the country. In the chapter dealing with the development of the coastal and high sea fisheries, and the fishing craft used we find a much appreciated historical account. The increasing intensity of the Icelandic sea fishery sets one wondering. A very surprising result is the catch of herring from Icelandic fishing vessels. The following numbers indicating the quantity of salted herring show the growth of the catch during 30 years:—

1897	7895	hektoliters
1907	27599	—
1917	104212	—
1927	497347	—

In the following chapter on the present position of the Icelandic fishery is given a number of details regarding the fishery for the different kinds of food-fishes, followed by statistical data concerning the total catch and the export of fishery products, and concluding with a brief account of the sealing and whaling in Icelandic waters. Then follows a description of the various kinds of fishing vessels used at different times by Icelandic fishermen, the open rowing and sailing boats, the decked sailing vessels, the open and the decked motor vessels and the steamboats. This account contains valuable data demonstrating the development of the Icelandic fishing float during recent years. The rowing and sailing boats are decreasing to this extent:—

Rowing boats: 1922: 901 and 1927: 650.
Decked sailing boats: 1922: 40 and 1927: 1.

The number of motor and steam boats is on the other hand increasing:

Decked motor boats: 1922: 494 and 1927: 676.
Steam-liners: 1922: 6 and 1928: 32 and
Trawlers: 1922: 31 and 1927: 46.

After a short account of special fishing gear and methods of fishing a fairly comprehensive description is given of all the more important landing-places and ports in Iceland. Here we find another striking example of the increasing intensity of the Icelandic sea fishery in the statistical data regarding the fishery of the Vestmanna Islands during this century. In 1900 we have 69 rowing boats and a total catch of 1593 tons and in 1927 no rowing boats but 95 motor vessels and 1 steam-liner giving a total catch of 16942 tons.

The report is concluded with a section on the administration and the legislation of the Icelandic sea fishery.

Dr. SAEMUNDSSON's valuable contribution to fishery literature is fully illustrated with many photographs and drawings provided by the author himself and others, and no one can read the report and fail to obtain an accurate idea of the development and the present state of the Icelandic sea fisheries.

P. JESPERSEN.

L. JOUBIN (edited by). Faune Ichthyologique de l'Atlantique Nord. No. 4. Cons. perm. Int. pour l'Exploration de la Mer. A. Høst et fils. Copenhague.

The fourth part of this work includes twenty-four sheets, bearing the names of such well-known authorities as D'ANCONA, CLARK, EHRENBAUM, FAGE, HELDT, and SCHNAKENBECK, and dealing with the following species: *Petromyzon marinus*, *Scyliorhinus* (*Scyllium*) *canicula*, *S.* (*Scyllium*) *stellaris*, *Etmopterus spinax*, *Acanthorhinus carcharias*, *Pristiurus melanostomus*, *Notidanus* (*Hexanchus*) *griseus*, *Raia naevus*, *R. undulata*, *R. montagui*, *R. lintea*, *R. clavata*, *R. brachyura*, *Ophisoma balearicum*, *Balistes capriscus*, *Congermuraena mystax*, *Belone belone*, *Engraulis encrasicholus* (2 sheets), *Rhombus maximus*, *Lepidorhombus whiff*, *Scophthalmus norvegicus*, *S. unimaculatus*, *Drepanopsetta platessoides*. CLARK's recent monograph of the European Rays forms a very important contribution to the taxonomy of this difficult genus, and the sheets for which he is responsible in the present work should be of great assistance in identifying these fishes. The descriptions of the Sharks and Dogfishes, for which EHRENBAUM is responsible, appear to be of special interest, as are those of the Flatfishes by SCHNAKENBECK, although his use of DAY's figures to illustrate *Scophthalmus unimaculatatus* and *Drepanopsetta platessoides* is to be regretted. In the case of the Anchovy, Gar-fish, and the two Eels, descriptions and figures of the larval or young stages are included in addition to those of the adult fishes.

This part, like those already published, is under the editorship of Professor JOUBIN, and fully maintains the standard set by its predecessors.

J. R. N.

R. SPÄRCK. Studies on the Biology of the Oyster (*Ostrea edulis*) VI– VIII. Report of the Danish Biological Station, XXXV, Copenhagen, 1929.

These short studies occupy 8 pages of the Report. In the first study (No. VI) the author re-examines his data on the spawning of oysters (*O. edulis*) in the Limfiord in 1919—1921 in the light of recent work on lunar periodicity in spawning. A few additional observations on spawning in September 1928 are also given. The incidence of spawning in *O. edulis* in the Limfiord where tidal changes are slight (The Admiralty Tide Tables, London, gives a mean rise of tide at Thyboron, situated outside the Limfiord, of only 1.5 feet) is of great interest, and is comparable with FOX's investigations on Centrechinus in the Mediterranean. SPÄRCK concludes from his records "that, in any rate, two years, 1919 and 1928, a maximum of spawning has been ascertained at new moon, and that a regular lunar periodicity in the spawning of the oysters in the Limfiord is out of the

question". When the records are examined it is found that maximal spawning occurred on two occasions during the periods of examination. In view of the importance of the subject the reviewer suggests that a new *ad hoc* investigation would be well worth undertaking. If this were done, it would be necessary to record not only details of the quantity, locality and dates of fortnightly samples, with bionomical description of the localities, but also description of the stage of development — or the age — of the larvae found in each of the breeding oysters. Indeed if, during SPÄRCK's maximal spawning periods, the majority of the oysters were in the black sick condition, spawning must have occurred at least 5 and possibly 10 or more days earlier. In that event the actual maximal spawning was as near full as new moon. SPÄRCK does not give any details of the condition of development — and therefore the approximate age — of the larvae carried by the spawning oysters.

In study VII, the author describes simple experiments which prove that shelled oyster larvae can live from 4 to 5 weeks in water cooled to a temperature of 2° to 5° C.; in one case the larvae were subjected to a temperature below 0° C. and still lived for about a month afterwards at 2° C. He concludes, however — from the failure of his own experiments — that "it also appeared that it was impossible at higher temperatures (10°, 12°, 18° C.) to keep larvae alive for more than 8 days at the most." Nevertheless PETERSEN kept larvae alive for a fortnight at 15° to 18° C.; LACAZE DUTHIERS kept them 30 and 43 days respectively; the reviewer has kept them in good numbers in a small honey-jar for six weeks in the laboratory on a slate slab at summer temperatures. In the remaining part of the section five experiments on the oxygen consumption of oyster larvae are given. The results obtained are variable and are perhaps best regarded as interesting preliminary and suggestive work.

No. VIII is a study of the mortality among Dutch oysters relaid in the Limfiord. The mortality was determined by examinations of catches of "some hundred oysters on the ground in question" but no details of the catches are given. It is stated that young Dutch oysters relaid in Nissum Broad show a lower mortality (15 to 25 %) than occurs among somewhat older native oysters (20 to 30 %) and that "the mortality seemingly is the most effective towards the end of the summer and this appears to me..... must above all be due to lack of food". Such a conclusion demands further researches correlating the amount of food available (as in SAVAGE's work) and the contemporaneous mortality. It would be interesting to know whether an autumnal maximum as well as a spring maximum occurs in the phytoplankton in the Limfiord.

J. H. O.

ALF DANNEVIG. Laks vekslingen i fiske og bestand. Årsberetning vedkommende Norges Fiskerier 1929. Nr. IV. Bergen, 1930.

The author has endeavoured in the present paper to give a brief account of the actual problems in the sphere of salmon fishing, and, in the first instance, of the causes of the great changes in the salmon fishery.

In the first chapter the biology of the salmon is dealt with concisely

and intelligibly, the author basing his remarks chiefly upon the results arrived at by other investigators. On the whole, this section does not contain anything really novel, but certain view points are put forward which may possibly arouse opposition or at least thought, and in any case should give rise to renewed research into certain interesting, and not as yet fully elucidated, particulars of the biology of the salmon. Thus, for example, the author maintains that if a long salmon river is built over at the mouth, so that the salmon's entry to the upper spawning grounds is prevented or hindered, the valuable spring salmon will diminish, while the less valuable autumn salmon, which spawns in the lower reaches of the river, remain. Likewise the author considers that the spawn of spring salmon breeds spring salmon, spawn of autumn salmon on the other hand autumn salmon, and he tries to explain this by the alternation which, at least in the case of some rivers, can be traced between the period of stay in river and in sea. The spawn of the spring salmon is large, the growth of the young salmon is rapid, the emigration therefore early, but the stay in the sea prolonged, and the length and weight, consequently, good, when the salmon returns to spawn for the first time. As, however, not only such an inverse corelation between the stay of the salmon in river and sea could be proved everywhere — but rather the contrary — and as both through Jacobsen's and Johansen's as well as through the reviewer's researches it has been proved or made probable that a high summer temperature hastens the salmon's sexual maturity and migration to the spawning place up-river, and, consequently turns a prospective big spring salmon into a smaller autumn salmon, the author's idea on this question, as he himself emphasizes, appears to require further investigation.

In the second chapter the author, on the basis of different documents, gives a very valuable account of the changes in the salmon fishery in Norway during different eras. Thus, the salmon fishery was particularly poor during the years 1836—1840 and 1875—1880, but, on the other hand, uncommonly profitable during the years 1885—1890—1900. The variations have frequently tended in the same direction in the case of neighbouring rivers, and even in the case of very large areas; in other instances, again, neighbouring rivers have not displayed any corelation in this respect.

In the third chapter the author deals with the various factors that may have caused the aforesaid variations, and particularly the great drop in the salmon fishery. As a very important factor for causing a poor fishery the author mentions low winter temperature in the sea, and he demonstrates how a poor fishery and diminution of the fat content in the liver of the cod mostly coincide. The food in the sea is possibly scarce at fairly low winter temperatures, the scarcity retarding the salmon's sexual maturity and growth, as well reducing the liver fat content of the cod. This is, however, contradicted by the fact that, in so far as a low winter temperature delays the salmon's migration up-river, the salmon fishery should be extremely profitable during the ensuing year. All researches relating to the salmon have in fact shown that the salmon does not live in the sea more than at the outside 4 or 5, in some odd instances 6, years before migrating up-river for spawning. No very long periods of poor salmon

fishery appear, therefore, to be due to low sea temperatures, but rather to annual changes in the offspring.

In the case of the southern salmon rivers in Norway the author assumes factors which affect the rivers themselves, e. g. the degree of acidity of the water, early high water in autumn, etc. A comparison with the corelation between the water level conditions of the rivers and the variations in salmon fishing demonstrated by the reviewer, as a matter of course, supplies in respect of the Norwegian rivers with their water level conditions quite a different result from those in the Swedish rivers.

A more intimate knowledge of the factors which cause variations in salmon fishing, as well as of the biology of the salmon, is naturally extremely desirable, for which reason DANNEVIG's paper should be welcomed with pleasure by all investigators of the salmon. It gives hints both for fresh research in the matter and for certain guiding principles.

GUNNAR ALM.

G. HERBERT NALL. Sea Trout of the River Tweed. Fisheries, Scotland, Salmon Fish., 1929, No. V. Edinburgh, 1930.

The investigations on the growth and habits of sea trout in Scottish waters, commenced by Mr. W. J. M. MENZIES, have been continued by Mr. G. H. NALL. These investigations have consisted of marking experiments and the examination of collections of scales.

The migrations of the salmon from the river to the sea and back again are relatively simple. It returns to the river only for the purpose of spawning. In the case of the sea trout, however, it is usual to find that a large proportion of the fish caught in fresh water are immature, that is to say, they will not spawn during the subsequent winter. Moreover the salmon, or at any rate those caught in British waters, usually have well-defined periods of rapid and slow growth which are indicated on their scales and which correspond broadly to summer and winter growth. Mr. NALL has shown that in the Beauly Firth and Inverness Firth the sea trout may feed freely on the shoals of sprats and small herring which invade these waters during the winter months. Under such conditions the sea trout grow rapidly and growth is represented on the scales by open ridges instead of by the close ridges characteristic of slow winter growth. Checks in growth during the sea life are shown on the scales of sea trout much more frequently than on those of salmon. Variation in rate of growth is much greater in sea trout than in salmon. These conditions add very considerably to the difficulties of interpreting correctly the scales of sea trout. Mr. NALL has attempted — and in the main has succeeded — to overcome these difficulties by the use of methods described in a previous report[1]).

The present paper deals with sea trout from the River Tweed and is based on the examination of 3,197 sets of scales. The great majority of

[1]) G. H. NALL. Sea Trout from the Beauly Firth and from the Tidal Waters of the Beauly and Ness Rivers. Fisheries, Scotland, Salmon Fish, 1929, No. III.

these came from fish taken in the nets at Berwick-on-Tweed. Some 596 sets of scales came from fish which had been marked and liberated.

The River Tweed is a little over 100 miles in length and it has a large number of tributaries, some of which are important for angling. It drains an area of about 1,500 square miles. It has no important lakes in its course and has a long stretch of tidal water. It is very heavily netted for the last 16 miles of its course and has a long netting season, from mid-February to mid-September. The ascent of salmon and sea trout is impeded by numerous weirs and there is a considerable amount of industrial pollution. These disadvantages are to some degree offset by the high quality and great extent of the available spawning grounds.

The characteristics which distinguish the sea trout of the Tweed from those of any other Scottish river are (1) the large size attained; (2) the rapid growth during sea life; (3) the great variation in growth rate and (4) the unusually high proportion of mature fish which do not spawn annually. The average weight of all the clean fish from which scales were taken was 4.43 lb. 54 per cent. of the captured fish were between 4 and 9 lb. in weight, 5.3 per cent. were 10 lb. or over. In size these trout resemble those found in certain rivers flowing into the Baltic. The average weight of Tweed sea trout which have spent 2 winters in the sea is about $4^1/_2$ lb., indicating a rate of growth which almost approaches that of the salmon and which is more than twice as great as that of sea trout from any other Scottish river. The heaviest trout in the collection was 22 lb. Mr. Nall expresses the opinion that the rapid growth and great size attained by the Tweed sea trout is due to the probability that many of them, during their sea life, travel far in quest of food and, in addition, the majority of them probably spend a longer proportion of their post-migration life in the sea than is usual amongst Scottish sea trout. The great variation in growth rate is attributed to differences in the character of the spawning grounds and of the streams in which the young fish spend the earlier part of their lives; and to differences in the feeding grounds in the sea to which they resort after migration.

The parr of Tweed sea trout grow rapidly and migrate at an early age. 79 per cent. migrated to the sea when 2 years old, 20 per cent. when 3 years old and 1 per cent. when 4 years old. The 2 year smolts average 18.3 cms. in length, the 3 year smolts 21.6 cms. The age composition of the stock, with the average lengths and weights of the various age groups, the averages of the calculated lengths of the various age groups at the end of each year, and other data are given in tabular form. The age at which maturity is attained is relatively late. 6.9 per cent. spawned during the first winter after migration, 62 per cent. during the second winter and 28.4 per cent. during the third winter. The length of life of Tweed sea trout is comparatively short, and as the attainment of maturity is late it follows that the fish do not spawn very frequently.

It was observed that in the case of some trout which had spent the winter in fresh water but which had not spawned, the scales showed slight erosion at the shoulder, sufficient, when growth was resumed, to present the appearance of a weak spawning mark. This is a point of considerable importance to those who are engaged in the examination of

trout scales and it is desirable that the evidence on which the opinion is based should be given in greater detail.

The number of sea trout marked in recent years in the Tweed was 596 and of these 131, or 22 per cent. were recaptured. Some fish were recaptured more than once so that the total number of recaptures was 153. Most of the recaptures were made soon after marking and before the trout had returned to the sea. Of the recaptured fish, 26 had been to sea and made new growth. Of these, twelve were caught in the Tweed or its tributaries, six in the Forth, two in the Tay, one in the South Esk, one off the Norfolk coast, three off the coast of Holland and one off the Jutland coast. These last five fish indicate that the migrations of the sea trout may be quite extensive. The examination of the scales of those recaptured fish which were again taken in the Tweed after intervals ranging from a few days to five months and which presumably had spent the interval in the river showed that no growth had been made and in many cases the fish had lost considerably in weight. This observation confirms the opinion previously held that sea trout do not grow during the periods when they revisit fresh water.

The opinion has long been entertained that the Tweed, in addition to ordinary sea trout, held a distinct race known as "bull trout", differing from sea trout in rapidity of growth, in habit and in appearance. After careful investigation Mr. Nall concludes that there is no basis for this opinion and that there is only one homogeneous race of sea trout in the Tweed. On p. 35 he says — "To one who believes, as I do, that local variations, or local races, are due simply to differences in local conditions, it is inconceivable that the same river should have two distinct races." This is somewhat obscure. Do the "local variations, or local races" in which Mr. Nall believes, occur in the same river, and if so do they differ from "distinct races"? Or, on the other hand, does he believe that local conditions in the same river are relatively uniform, so that "local variations or local races" or "distinct races" could not arise and maintain themselves there? This question of the occurrence of distinct races of the same species in the same river is of some interest in view of the growing opinion that the various seasonal runs of the salmon frequenting the same river differ from each other in their hereditary constitution to the extent that the Spring and Summer running fish produce only offspring having the same characteristics as their parents.

Mr. Nall, whilst not denying the possibility of such occurrence, has found no evidence of the existence of hybrids between salmon and sea trout.

In an appendix, a brief account is given of a small collection of sea trout scales from the River Coquet. The fish of this river resemble those of the Tweed in their high growth rate and habit. R. S.

N. A. Mackintosh and J. F. G. Wheeler. Southern Blue and Fin Whales. Discovery Reports Vol. I. pp. 257—540. Plates XXV—XLIV. Cambridge 1929.

In January 1925 the marine biological station in South Georgia was opened and, as a link in the recent Discovery investigations, a series

of studies of the whales brought into Grytviken harbour was taken in hand. This paper is the result of the observations made there from January 1925 to April 1927 and in Saldanha Bay, South Africa, in 1925. The material embraces 1577 blue and fin whales. This large number is impressive when it is considered how thoroughly each of the whales was examined, and the more so when one is oneself aware what it means to examine a whale at a station where the ordinary work has to go on at the same time without interference.

The investigations were centred on the solution of three essential problems:—

1) The determination of the characters of southern blue and fin whales and the detection of any possible sub-specific or racial distinctions such as might be associated with distribution or migrations.

2) An investigation of the reproductive processes, breeding habits and growth.

3) The examination of the interrelations of breeding, nourishment, distribution and local fluctuations of the whales.

The first problem is studied by a series of twenty four different measurements on each whale. It was not possible, in every case, to take all these measurements, but most of them were, however, taken in numbers which were quite sufficient to determine the body proportions of the species and the variations in the lengths measured. The results, which are arranged in synoptical tables and curves, show that there is no character present which can suggest any racial or sub-specific distinction between the whales at South Georgia and those off South Africa. The result so far is negative, but it is of exceedingly great value, as an unusually abundant material has here been arranged for comparison with material from all other possible localities where investigations have been carried out.

The most important result of the investigations made by the authors concerns the breeding and growth of the whales. There are here three sources from which material has been collected, viz.: 1) the examination of the genital organs, 2) the examination of foetuses and 3) the connection between the migration and habits of the whales and their breeding. The investigation of the genital organs has included the size and growth of the ovaries, the state of the follicles, counting of corpora lutea, the size of the uterus and whether there was a foetus present and the state of the mammary glands and, furthermore, the size of the penis, of the testes and of the histology of the testes. What is so particularly valuable in this series is the investigation of the corpora lutea. The first result attained is the determination of the lengths at which the blue and fin whales become mature. The authors have found the following average lengths:—

Blue whale	♀	23.7 m. (77′9″)
—	♂	22.6 - (74′2″)
Fin whale	♀	20.0 - (65′7″)
—	♂	19.5 - (63′8″)

These lengths are of exceedingly great importance in ascertaining how many of the captured stock are mature. Thus at South Georgia during

the period in question, 42.2 % of blue whales ♀ and ♂ were not mature, while of the fin whales there were 27.5 % immature females and 22.3 % immature males. These percentages are lower in the first half than in the second half of the whaling season — a circumstance that is of significance for the comprehension of the entire stock.

Earlier investigators in this field have known that gestation in the blue and fin whale lasts for very nearly a year and that there is a period during the winter when, at any rate, the maximum number of copulations occur. Mackintosh and Wheeler have procured an excellent material for penetrating further into this question. The follicles of the ovaries in whales may be large at any time of the year, but the majority of females without foetus or calves have small follicles early in the year and these follicles develop rapidly in April and May. A functional corpus luteum without a foetus was found in blue whales at South Georgia in March, May and October, in very small numbers in proportion to the many females captured at the same time. A functional corpus luteum, at South Georgia, is thus almost always a sign of the existence of a foetus. In Saldanha Bay, however, functional corpora lutea without foetuses were found in June and July in a large percentage of the few mature females examined there. The authors found the smallest foetuses of the blue whale in July and August, viz. one measuring 21 and one 33 millimetres. The simultaneous examination of the testes shows an increasing production of spermatozoa from April to July. The condition of the genitals therefore goes to show that June to July is the period when most of the copulations take place, but it also appears that many copulations occur in May, August and September.

Mackintosh and Wheeler have examined altogether fifty blue and eighty one fin whale foetuses and have, on the basis of length measurements, constructed a growth-curve for foetuses. The length at birth is determined fairly exactly by means of the largest foetuses found and the smallest calves captured. The calf of a blue whale is, on an average, 7 metres long when born, and that of the fin whale 6.5 metres. From the growth curve they have constructed, the authors find that the period of gestation lasts a good ten and eleven months for the blue and the fin whale respectively. Consequently most of the calves are born from March to July.

The further growth of the calves is studied in a similar manner. The average length at which the calf is weaned and begins to feed on krill is determined by means of the smallest calves with krill, and the largest with milk in their stomachs. The length for the blue whale is thus found to be about 16 metres and for the fin whale about 12 metres. This is also confirmed by the suddenly increased growth in the length of the baleen plates of these sizes. Even the growth curve for the time the calves are sucklings is found in a similar manner to that in the case of the foetuses, viz., by help of the measurements of the calves during the season. From the growth curve it can also be seen that it takes the calf six or seven months to reach the length at which it is weaned. It is apparent that this is a very rapid increase in length, viz. about six and nine metres in seven months for the fin and blue whale respectively. The further growth up to maturity is examined by means of the whaling statistics. By a

series of illustrative curves it is shown that the stock always has a tendency to assemble in groups of three sizes, different for each sex. As regards the blue whale the males are generally grouped in lengths of 18 to 19 metres, 21 metres and 24 metres and the females in lengths of 20 metres, 23 and 26 metres. Regarded in connection with the investigation of the genital organs these groups may be reckoned as 1) small immature, 2) large immature, and 3) mature animals. According to the opinion of the authors there is no reason to suppose that these groupings are accidental; on the contrary they must be regarded as year classes. On the basis of this the whole of the growth curve can thus be constructed. We find therefore that the blue and fin whales reach the age of maturity a good two years after birth. Mackintosh and Wheeler themselves are emphatic that this probable growth curve is most reliable in the beginning and the reliability decreases steadily towards the end. There are, however, many things from other investigations which support the authors' results in a convincing manner.

A problem of great importance for the whole stock is the birth rate among the whales. In respect of this question the authors have investigated the percentage of mature females with foetuses. Theoretically one would expect the percentage to be near 100, 50 and 33 if the whales bore a calf every first, second or third year. At South Georgia, during the period of examination, the percentage of pregnant females was 46 % for the fin whales and 31 % for the blue whales. As these are of course minimum values there can hardly be any doubt that, as regards the fin whale, a calf every other year is the normal state of things, but also as regards the blue whale the authors maintain that the percentage (31) is so high that a calf every other year is at any rate not unusual.

In the last chapter the authors deal with the stock of whales and discuss very thoroughly the composition of the stock in the two areas, South Georgia and South Africa. How matters stand at South Georgia will be clearly seen from the following table:—

Classes	Blue	Fin
Adult males	28 %	42 %
Immature males	21 -	13 -
Pregnant females	10	16
Lactating females	4 } 29 %	3 } 32 %
Resting or ovulating females	15	13
Immature females	22 %	13 %

The population at South Georgia is of a generalized character which suggests that the whaling returns give a representative picture of the actual composition of the stock. If this be so, it means that the whales' expectation of life is very small, as 30 to 40 % of the whales captured are immature animals, i.e., animals up to two years of age. a circumstance

that may possibly be attributed to the intensive whaling operations. The authors consider that it is possible for a decimated stock in an area to be renewed by a gradual immigration from neighbouring regions. The rapid growth of the whales is also favourable for the maintenance of the stock. They call attention, however, to the unusually high percentage of immature animals which are captured particularly at the South African stations and the comparatively slow propagation. Looked at from these points of view the whaling in South African waters is very uneconomical, and the stock here is exposed to the greatest injury.

It is, of course, impossible in these brief remarks to give an exhaustive resumé of this comprehensive paper. I have merely indicated some of the results I consider of most general interest, but I would advise all who are interested in the whale and whale investigations to make themselves familiar with this valuable and interesting work. The investigations are being continued at the station in South Georgia on the same lines, and we look forward with interest to the results which these efforts must produce. JOHAN T. RUUD.

(1) WALTHER ARNDT. Haltung und Aufzucht von Meeresschwämmen.
(2) ARTHUR HAGMEIER. Die Züchtung verschiedener wirbelloser Meerestiere. Handb. der biologischen Arbeitsmethoden. Abt. IX, Teil 5, Heft 4. Berlin, 1930.

In the first part of this section Dr. WALTHER ARNDT gives a full account of the methods of keeping and rearing marine sponges. As he truly remarks, it is difficult to keep sponges in small vessels without frequent changes of water, but in larger aquaria with running water certain species, especially those from shallow regions, can be kept with ease. Instructions are given for the collecting of various sponges and their larvae, and the best ways of keeping them in aquaria, including temperature, lighting and circulation, besides details as to food and precautions against enemies. The larvae have only been reared in a few special cases and much is still to be known about them as the proper food is not yet determined. Another section deals with culture in the open sea, the sponges being placed in perforated vessels or, in the case of commercial sponges, growing pieces being mounted on wood or cement. The whole gives a very good idea of the methods of sponge growing.

The second part is taken up with an extensive treatise on the different methods of rearing other marine invertebrates. Cephalopods, Echinoderms, Bryozoa and Gephyrea have already been dealt with in Lieferung 278 of the present volume. Professor HAGMEIER describes the rearing of many coelenterates, mollusks and Crustacea, most of which have planktonic larvae. An elaborate general introduction deals fully with the collecting methods including traps, dredges, bottom samplers and nets, with aquaria of all kinds for keeping and rearing the animals and with methods of circulation and aeration for large and small vessels. Much attention is given to the food of the adults with their special wants, the author dividing them into groups according to their methods of feeding. In this way it is possible to combine in certain aquaria animals whose food is different,

such as detritus feeders with carnivores and herbivores, the last feeding on the algal growth on the sides of the vessel. An enormous amount of research over many years has enabled us to know fairly well the needs of each animal and this knowledge is now brought together and used in an adequate way.

In describing the rearing of the planktonic larvae the researches of Allen and Nelson on pure diatom cultures are shown to be fundamental, so many larvae being successfully reared on these. *Nitzschia closterium* forma *minutissima* is the most general food used in this way. The planktonic larvae may be reared either from ripe eggs and sperm brought together by the worker, or from the already naturally fertilised eggs. Amongst the former are echinoderms and many worms and mollusks, amongst the latter most of the higher crustacea which carry their eggs and such mollusks and worms which either carry them or deposit them in capsules or gelatinous masses. The coelenterates also mostly belong to the latter category.

For the food of the growing larvae, besides diatoms, Fucus sperms, green algal spores and small flagellates are used, or in some cases water rich in detritus is best. Many larvae, however, require larger and essentially animal food. This is the case with most of the decapods which catch live prey such as mollusk and worm larvae. Oyster larvae are shown to be excellent as food for crab zoeae which also eat worm and echinoderm larvae in the very early stages before spicules and chetae have developed. Coelenterates, especially hydroids and medusae, must have plankton food, mostly copepods and young mollusks, some medusae and ctenophores, however, feeding much on others of their own kind. Not only are the general facts given in this work, but special instances are quoted in detail, such as, among the coelenterates, the rearing of Aurelia through all its stages with notes on other medusae, of Clava, Metridium and Alcyonium; among the Mollusca Acanthochiton, Cumingia, Syndosyma, Mytilus, Ostrea and Cardium; and among the decapods Homarus, Portunus and Carcinus.

This is a particularly important and valuable portion of Dr. Abderhalden's Compendium and will be a real boon to all those workers who are occupied with this very difficult but exceedingly interesting subject.

M. V. L.

Current Bibliography.

Prepared by the Editor with the assistance of Miss THURSBY-PELHAM.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in the North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

The classification of entries follows in a general way that adopted in Dr. ALLEN's Selected Bibliography published in Vol. I, Nos. 1 and 2 of the Journal, and since reprinted (Price, 1 Kr.).

Subscribers and those on the distribution list will receive regularly upon application to the Administrative Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

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